FINAL

# Summary Report
# Review and Evaluation of USACE Recommendations and Cost Estimates

**Delaware River Basin Commission**
**West Trenton, NJ**

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O'BRIEN & GERE

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## 1. PURPOSE

Technical review and independent evaluation of planned capital and O&M cost evaluations provide the basis for the determination of the adequacy of the current Surface Water Charging program and Water Supply Storage Fund and investigation of other funding mechanisms and increases in water charging rates.

Under this work, an independent evaluation of USACE's prior recommendations for upgrading Beltzville and Blue Marsh Dams to satisfy current dam safety requirements was conducted. Previous USACE cost estimates were reviewed, cost estimates were updated as appropriate for capital work items and operation & maintenance costs, additional or alternate approaches were identified and associated costs developed. Costs attributable to DRBC through their reservoir storage contracts with the United States government were projected over the next 30 years.

Under the next phase of the project, the identified capital and O&M cost projections for Beltzville and Blue Marsh Dams will be used to conduct an evaluation of the current water charging program to fully fund those costs, develop projected rates and fees to pay for expected costs, reexamine the methodology for charging water users in the basin, and propose changes to the water use charges and methodology to produce stable and predictable cash flows to cover DRBC's cost share for these dams.

## 2. APPROACH

The task approach was as follows:

- Met with USACE – Philadelphia District and discussed and reviewed USACE studies relevant to dam safety and proposed remedial measures at Beltzville and Blue Marsh Reservoirs
- Conducted site visits to Beltzville and Blue Marsh Reservoirs to view site conditions
- Determined if USACE construction and O&M costs over the next 30 years are reasonable to expect
- Evaluated and determined if any additional or maintenance items may be necessary beyond USACE recommendations
- Projected capital, operating and maintenance costs to support Beltzville and Blue Marsh Reservoir dam infrastructure needs over the next 30 years.

### 2.1. REVIEW SUMMARY STUDIES OF DAMS

O'Brien & Gere requested available USACE information relevant to dam safety and proposed remedial measures at Beltzville and Blue Marsh Reservoirs prior to any formal meetings. Documents requested included:

- As-built or record drawings from dam construction;
- All periodic inspections since the reservoirs were constructed;
- 2012 underwater inspection videos/reports;
- All contracts for the maintenance, repair or alteration of real property since the reservoirs were constructed, including costs or bids;
- All condition surveys (conduit crack surveys);
- Hydraulic steel structures (HSS) inspection reports;
- Piezometer/observation well data/logs;
- Other instrumentation data/surveys;
- Tower monitoring program reports; and
- Other relevant O&M records including costs for manpower, materials or contractors
- Cost estimates for proposed capital projects.

Currently identified deficiencies at both reservoirs include:

- The freeboard criterion for either dam is not satisfied under current Probable Maximum Floods (PMFs);
- The internal filter drain systems for the dams do not meet current USACE standards for dam safety:
- Potential need for repair of the outlet tower at Beltzville Dam, which has been affected by alkali aggregate reaction (AAR).

O'Brien & Gere Engineers, Inc. (O'Brien & Gere) and DRBC staff met with USACE staff in their Philadelphia office on December 17, 2012 to discuss the Corps of Engineers Dam Safety process and review requested documents. Both dams have undergone a Screening for Portfolio Risk Analysis (SPRA) under the Corps' Dam Safety Portfolio Risk Management Process in 2009. These documents are For Official Use Only provided under a confidentiality agreement and are not included herein. Both dams have a Dam Safety Action Classification (DSAC) rating of DSAC III, HIGH PRIORITY (Conditionally Unsafe). Characteristics of this class are SIGNIFICANTLY INADEQUATE OR MODERATE TO HIGH RISK – meaning that for confirmed or unconfirmed dam safety issues, the combination of life, economic or environmental consequences with probability of failure is moderate to high. Actions for dams in this class are:

- Implementation of interim risk reduction measures, including operational restrictions as justified
- Emergency Action Plan is current
- Conduct heightened monitoring and evaluation
- Prioritize for investigations to support justification for remediation

Based on these ratings, USACE advised us that the Beltzville and Blue Marsh dams were not planned to undergo remedial measures for at least 20 years into the future, based on current funding and prioritization. DRBC was formally notified by USACE of the DSAC rating on April 1, 2010.

Major identified deficiencies at both dam sites were discussed.

- Improvements to the dams to meet the freeboard criterion under Probable Maximum Flood (PMF)
  - This condition was not deemed a major need since the benefits of spillway modification are limited ;

- The internal filter drain systems for the dams do not meet current USACE standards for dam safety (EM 1110-2-2300 (30 July 2004)- General Design and Construction Considerations for Earth and Rock-Fill Dams ; EM 1110-2-1901 Seepage Analysis and Control for Dams (30 April 1993)):
  - Both dams were constructed with a random fill zone between the impervious core and the vertical (chimney) drain

- Potential need for repair of the outlet tower at Beltzville Dam, which has been affected by alkali aggregate reaction (AAR), was confirmed.

The USACE Dam Safety Investment Plan (DSIP) in 2011 estimated costs for rehabilitation of Beltzville and Blue Marsh Dam safety needs at $17.9 million and $105.3 million, respectively. Independent estimates by Philadelphia District staff placed the estimated costs for rehabilitation of Beltzville and Blue Marsh Dam safety needs at $18 million and $8 million, respectively. These estimates were provided on December 17, 2012 and included as Appendix A.

A preliminary review of available studies and documents was conducted on December 17, 2012. Subsequent to the meeting, USACE provided O'Brien & Gere with electronic files of scanned documents for both dams, consisting primarily of "as-built" drawings, design memoranda, condition reports, periodic inspection reports, and piezometer data. In the period of January through April 2013, additional information was conveyed to O'Brien & Gere including the DSIP worksheets, provided on January 25, 2013, outlining the issues to be remediated and remediation concepts. A construction cost summary associated with the DSIP worksheets was also provided. These documents are For Official Use Only provided under a confidentiality agreement and are not included herein. No detailed backup of construction costs was provided. On April 12, 2013, the 2006 CARPI budgetary estimate for controlling AAR at the Beltzville Dam Intake Tower was provided. This program was for the installation of a geomembrane system to cover and waterproof the entire exterior face of the tower. The CARPI budgetary estimate is $1.4 million and is included as Appendix B. A summary of background documents reviewed is included in Appendix C.

A particular document of interest noted in discussions with USACE is a field investigation conducted at Beltzville Dam by the engineering firm, Gannett-Fleming. This field investigation was an infrared study of the downstream face of the dam to investigate temperature anomalies that may indicate seepage issues. This study was not released to O'Brien & Gere since it is undergoing USACE review and its security classification is unclear.

## 2.2. SITE VISITS TO BELTZVILLE AND BLUE MARSH RESERVOIR DAMS

O'Brien & Gere conducted site visits on February 6, 2013 to both the Beltzville and Blue Marsh Reservoirs with USACE and DRBC personnel familiar with the dams. The purpose of these visits was to view and familiarize O'Brien & Gere with the existing conditions of the dams, outlet structures and associated infrastructure. Particular focus was upon the remedial actions proposed by the USACE and locations of such repairs/needs so the nature and extent of these measures could be further described in the field by the personnel who developed the approaches and cost estimates. This field visit also served as a basis for identifying any additional dam safety measures or maintenance items that might be necessary over and above those items identified by USACE.

At the time of the site visits there was no snow cover so that the dam embankments and appurtenant features were observable. At Beltzville and Blue Marsh Dams, the dam embankment, spillway channel, intake tower interior and outlet works/stilling basin were viewed. In addition, at Blue Marsh Dam, Dikes A, B and C were viewed during the site visit.

### 2.2.1. Beltzville Dam

At Beltzville Dam, items of particular interest during the site visit were the intake tower alkali-aggregate reaction (AAR), also known as alkali-silica reaction (ASR), and the downstream face of the dam. The Gate Chamber (El. 518.0 to 548.0) had significant efflorescence and/or exudations of alkali-silica gel on the concrete walls and ceilings. USACE dam maintenance staff stated that they have scraped the walls and drain channels in the floor as part of an ongoing program. Survey monuments on the tower exterior, for monitoring structural expansion due to ASR, were pointed out during the site visit. The reference document for this subject is the USACE Philadelphia District report by Acres International Corporation dated October 1996 entitled "Beltzville Intake Tower – Alkali-Aggregate Reaction Impacts on Structural Performance and Operation." The study concluded that there were no obvious signs of serious structural distress from ASR, the ASR expansion was occurring in all three dimensions, and extrapolation of the data indicated that in the next 25 years (by 2021) the accumulated stress may create significant deterioration of tensile strength and rebar bond strength. Under extreme or unusual loads, the combination of leakage, corrosion and ASR has the potential to reduce the structural adequacy and safety of the intake tower. Recommendations included investigating rebar corrosion and checking the design under a full range of load cases. If the intake tower safety is demonstrated with this program, continue with a second tier of recommendations. These recommendations included a survey program to monitor vertical expansion of the tower, assessment of operation and data collection systems, periodic inspection and monitoring for cracks, signs and extent of corrosion and tests for loss of concrete strength and rebar tension, and consideration of the application of a robust waterproof membrane system to reduce the rate of the reaction. No recent documentation on the investigation of the ASR situation or monitoring data on the rate of structural expansion appears to be available for Beltzville Dam.

A walk-over of the downstream slope of the dam did not indicate any readily definable areas of seepage, however, some moist areas were observed. Evidence of what appeared to be the field stake-out/ marking from the Gannett Fleming investigation was also observed. This consisted of flagging and delineated areas over numerous portions of the downstream face. Immediately adjacent to the left abutment, there is a pipe and discharge pool which is not on the "as-builts" and may be an abutment drain. The water was clear and there was no evidence of sediment on the bottom of the pool.

### 2.2.2. Blue Marsh Dam

The particular item of interest at Blue Marsh Dam is seepage along the downstream slope near the toe of the dam. A walk-over of the downstream toe area included observation of the piezometer system, the seepage monitoring pool, and the left abutment area. The seepage monitoring pool has a V-notch weir and appeared to have had a depth recording apparatus at one time. The pool is fairly sizeable; no observation of the pool bottom was possible since it appeared to be covered with a vegetative mat. USACE staff pointed out an area along the groin between the downstream face and the left abutment mid-slope where small boils of water have appeared in the past. There did not appear to be any loss of soil at this location.

## 2.3. USACE WORK ITEMS AND COSTS

The DRBC cost share for each project joint use elements for water storage space at Beltzville and Blue Marsh Dams is based on DRBC's contracts with the U.S. government executed in 1966/1980 and 1971, respectively. For Beltzville Dam, DRBC is required to pay: 100 % of the cost of any major replacement of specific water supply facilities; 30.98 % of joint use major replacement items; 100 % of the annual operation and maintenance expense of specific water supply facilities; and 31.01% for joint-use operation and maintenance expenses. For Blue Marsh Dam, DRBC is required to pay: 100 % of the cost of any major replacement of specific water supply

facilities; 11.765 % of joint use major replacement items; 100 % of the annual operation and maintenance expense of specific water supply facilities; 12.698 % for joint-use operation and maintenance expenses until such time as the storage for water is first used; 25.397 % for joint-use operation and maintenance expenses thereafter. For Blue Marsh Dam, first use of water storage occurred in 2010.

Major replacement (dam modification) items and costs identified by USACE:

- Beltzville Dam
    - Reconstruct internal filter drain system and extend grout curtain - $17.9 million (2010)
    - Intake Tower CARPI geomembrane system - $ 1.4 million (2006)
- Blue Marsh Dam
    - USACE DSIP
        - Install cutoff wall along entire length of dam (1,850 feet) and Dike A using Hydromill panel method
        - $105.3 million (2010)
    - USACE Philadelphia District
        - Reconstruct internal filter drain system
        - $ 8 million (2010)

The estimated joint use annual operation, maintenance, and administrative costs were identified from the USACE actual costs of $1,200,000 for Beltzville Dam billed in Fiscal Year 2012 and $800,000 for Blue Marsh Dam billed in Fiscal Year 2012. These costs are representative of the joint use general operation and maintenance costs for each project. Detailed backup of these costs was not provided in written form.

Following the site visits, the O'Brien & Gere team began review of the construction cost estimates, the maintenance recommendations and associated estimated costs developed by USACE. The December 2008 USACE/ DRBC report entitled "Enhancing Multi-jurisdictional Use and Management of Water Resources for the Delaware River Basin, NY, NJ, PA, and DE" was reviewed as a starting point. Section 5 - RE-EVALUATE APPROACH TO USER SUPPLY COSTS TO SUPPORT FLOW MANAGEMENT AND EQUITABLE ALLOCATION GOALS included several tables that became the starting point for developing updated tables of capital and O&M costs. Tables 5.1, 5.2 and 5.3 project Water Supply costs on a work item basis from 2007 through 2030 for the estimated annual operation, maintenance, administrative and major repair/upgrades costs. O'Brien & Gere and DRBC met with USACE staff on February 25, 2013 to review these tables on a work item basis. Each work item listed in the tables was reviewed for its description, completed or projected status, and estimated cost in current dollars. New work items and costs were added based on recent experience with major upgrades/ repairs and the projected fiscal year for implementation was selected. Work items and costs that were deemed reasonable and considered to be necessary within the next 30 years were summarized in updated tables for both dams. Subsequently, the major repair/ upgrade tables were then forwarded to USACE Philadelphia District for review and confirmation or revisions.

## 2.4. ALTERNATE APPROACHES/ COST ESTIMATES

Subsequent to the review of documents, the site visits, and meetings and discussions with USACE staff, the O'Brien & Gere team prepared alternate approaches and cost estimates. These alternates were developed based on the team's assessment of the methodology and level of detail used in developing the cost estimates, the lack of documentation for the cost estimates, and the completeness of the identified concept and construction means and methods. For the CARPI geomembrane system, the budgetary cost estimate was updated to a project level cost estimate by including omitted items and contingency.

### 2.4.1. Interim Remedial Measure – CARPI Geomembrane System

CARPI, established in 1963, uses synthetic geomembranes in a patented system for the waterproofing and protection of all types of hydraulic structures (concrete, RCC and embankment dams, reservoirs, canals, tunnels), underground structures and civil works. For Beltzville Dam, the purpose of this system would be to reduce the potential for water permeation into the concrete, which can accelerate AAR, and to mitigate concrete expansion. CARPI prepared a budgetary estimate of $1.4 million for the exterior waterproofing on the Beltzville Intake Tower in 2006. This estimate, which is included in Appendix B, denotes a number of items of work and/or costs that were not included in the budgetary estimate. Using the CARPI budgetary estimate as a base, a preliminary construction and project cost estimate was prepared by escalating the costs to FY 2013, adding omitted items and including a contingency of 35 %. Of particular note was the added construction item of providing an elastomeric coating system to waterproof the Water Quality Wells, which are on the interior of the tower but exposed to contact with water. The independent preliminary construction and project cost estimate for installation of the CARPI system, included as Appendix D, is $5.5 million FY 2013.

### 2.4.2. Major Replacement (Dam Modification) Costs

The major replacement costs for both Beltzville and Blue Marsh Dams represent significant future infrastructure investments. Based on discussions with USACE Philadelphia District, it was agreed that it was appropriate for this study to use the District's approach for rehabilitation. For the reconstruction of the internal filter drain systems, limited description of the USACE concept for rehabilitation was provided – "excavate downstream face and install new filter." As a result, O'Brien & Gere independently developed cost estimates for this rehabilitation concept. The approach developed for each dam included excavating and stockpiling random fill and filter materials from the downstream face of the dam, exposing the impervious core and the horizontal (blanket) filter drain, extending the blanket drain to the impervious core, constructing a new chimney filter drain against the impervious core, and placing the stockpiled random fill as the new downstream face of the dam. The USACE methodology associated with this rehabilitation approach is not fully developed since no construction method to support the impervious core has been identified. The constructability of removing the downstream shell and exposing the steep impervious core of either dam is a significant issue that could render this approach infeasible.

At Beltzville Dam, the proposed rehabilitation concept included the installation of a two-line grout curtain from Station 7+330 to Station 5+700. In the existing construction, the cutoff trench and grout curtain extend only to Station 7+330. USACE DSIP analysis indicates the potential for flows through open fractures in contact with pipeable materials under unusual or extreme pool levels. The piezometer at toe of right abutment responds to pool levels. An independent cost estimate was also prepared for this rehabilitation element.

The independent preliminary project cost estimate for reconstruction of the internal filter drain system and two-line grout curtain for Beltzville Dam is estimated at $36 million FY 2013. For Blue Marsh Dam, the independent preliminary project cost estimate for reconstruction of the internal filter drain system is estimated at $8.7 million FY 2013. These cost estimates are included in Appendix D.

The independent preliminary project cost estimate for rehabilitation of Blue Marsh Dam indicates that there is no significant difference between the USACE Philadelphia District's estimate and the independent cost estimate developed herein. For Beltzville Dam, the reason for the significant difference between the USACE estimate and the independent estimate cannot be identified since no detailed means and methods or cost estimate breakdown was available for the USACE estimate.

Additional investigations and studies need to be conducted to verify the feasibility of this method for reconstruction of the internal filter drain system. Nonetheless, it is appropriate to plan for a significant infrastructure investment at each of the dams and the above cited costs can serve that function until further investigations demonstrate a basis for modification.

## 2.5. ADDITIONAL REPLACEMENT OR MAINTENANCE ITEMS

The internal filter drain systems for the dams do not meet current USACE standards for dam safety since both dams were constructed with a random fill zone between the impervious core and the chimney drain. The piezometer data from both dams suggest that the phreatic surface is at or slightly above the horizontal (blanket) portion of the drain system at the dam foundation. (Refer to preliminary figures in Appendix E). At the current time, no information is available to evaluate the effectiveness of the internal filter drains at either dam site. If seepage and potential piping of fine-grained materials are ongoing concerns, installation of a toe drain system would be a reasonable measure to control seepage in advance of replacement of the internal filter drain system. The toe drain system would consist of the placement of perforated HDPE piping within a graded filter drain zone that ties into the existing blanket drain at the toe of the dam. Weir boxes would be installed at critical locations in the system for monitoring seepage. At Beltzville Dam, the existing blanket drain is 3 feet thick; at Blue Marsh Dam the blanket drain ranges between 3 and 5 feet thick. At Beltzville Dam, the toe drain system would only be installed between Station 7+300 and Station 9+900; at Blue Marsh Dam, the toe drain system would be installed between Station 11+50 and Station 19+50. The toe drain system at each dam would enable monitoring of seepage flow over the weirs and the weir boxes would trap any soil particles that may be transported due to ineffectiveness of the internal drain system.

Independent preliminary project cost estimates were developed for installation of toe drains at both dams and are included in Appendix D. For Beltzville Dam, the estimated cost in FY 2013 is $3.9 million; for Blue Marsh Dam, the estimated cost in FY 2013 is $1.3 million. These costs include a contingency of 35 %, consistent with the level of project definition and end usage.

## 2.6. INTERIM REMEDIAL MEASURES

### 2.6.1 Piezometers

Additional piezometers are recommended to be installed at Beltzville Dam. Three piezometers could be installed along the downstream slope and at the toe between the outlet conduit channel and the left abutment to further assist in the assessment of the blanket drain performance and to provide additional information regarding possible artesian conditions at the toe. Two additional piezometers are recommended in the area of the proposed grout curtain to monitor current conditions and the effectiveness of the extended grout curtain from Station 7+330 to Station 5+700 after construction. The estimated cost for the five piezometers is $50,000 FY2013 and is included in the major repairs/upgrades cost tables since USACE would likely place it in that category.

## 2.7. CAPITAL, OPERATING AND MAINTENANCE COST PROJECTIONS

Capital, operating and maintenance costs to support the Beltzville and Blue Marsh Reservoirs dam infrastructure needs were estimated in FY 2013 dollars. The USACE terminology for these costs is major repairs/upgrades and that terminology will be used. The projected time periods for implementation over the next 30 years were identified. The basis for the inclusion/exclusion of work item costs, the source for cost data related to each category of cost, and the estimated costs to be included for the time periods were reviewed and confirmed with USACE.

These costs were tabulated on a work item basis and projected to the fiscal year of implementation in summary tables. Costs were projected using the Engineering News Record (ENR) Construction Cost Index (CCI). Ratios of CCIs for several periods of record were analyzed and converted to annual escalation rates. To create a cost "envelope", high and low escalation rates were selected for projections of both capital and operating costs for the dams, given the long term nature of the projection. The high projection of 4.5 % was based on the ENR CCI

period between 1926 and 2012, the entire period of record; the low projection of 3.2 % was based on the period from 1982 to 2012.

DRBC's cost share for each work item for project joint use elements for water storage space was applied per the 1966/1980 Beltzville Reservoir or the 1971 Blue Marsh Reservoir water storage contract with the United States or as modified by DRBC.

These summary tables are presented in the Tables section and include:

- Table 2-1 - Beltzville Dam Estimated Annual Operation & Maintenance Costs (both high and low projections)
- Table 2-2 - Blue Marsh Dam Estimated Annual Operation & Maintenance Costs (both high and low projections)
- Table2-3 - Beltzville Dam Estimated Major Repairs/Upgrades Costs – Low Projection
- Table 2-4 - Beltzville Dam Estimated Major Repairs/Upgrades Costs – High Projection
- Table 2-5 - Blue Marsh Dam Estimated Major Repairs/Upgrades Costs – Low Projection
- Table 2-6 - Blue Marsh Dam Estimated Major Repairs/Upgrades Costs – High Projection
- Table 2-7 - Beltzville/ Blue Marsh Dams Estimated Major Replacement Cost Programs – Low Projection
- Table 2-8 - Beltzville/ Blue Marsh Dams Estimated Major Replacement Cost Programs – High Projection

These tables provide the estimated future capital and operation and maintenance cost bases for the subsequent funding reserve analysis of the Water Supply Fund, and the reexamination of the methodology for charging water users in the Delaware River Basin and for developing a water charging program that generates a sustainable revenue stream for the foreseeable future.

## 3. SUMMARY

The O'Brien & Gere team completed an independent evaluation of USACE's prior recommendations for upgrading Beltzville and Blue Marsh Dams to satisfy current dam safety requirements. Previous USACE cost estimates were reviewed and updated as appropriate for capital work items and operation & maintenance costs, additional or alternate approaches were identified and associated costs developed. Costs attributable to DRBC through their reservoir storage contracts with the United States government were projected over the next 30 years. The annual escalation percentages were 3.2% and 4.5%, based on historic ENR Construction Cost Indices over extended periods.

For major replacement (dam modification) items and costs identified by USACE, commentary is as follows:

- Beltzville Dam
    - Reconstruct internal filter drain system and extend grout curtain - $17.9 million (USACE 2010)
        - The O'Brien & Gere team estimate is significantly greater at $36 million FY2013
        - Additional investigations and studies need to be conducted to verify the feasibility of the proposed method for reconstruction of the internal filter drain system. The proposed method would only be feasible if the reservoir pool is significantly drawn down.
    - Intake Tower CARPI geomembrane system - $ 1.4 million (2006)
        - The O'Brien & Gere team estimate is significantly greater at $5.5 million FY 2013
        - The difference is based on adding omitted items and including a contingency of 35 %. Of particular note was the added construction item of providing an elastomeric coating system to waterproof the Water Quality Wells, which are on the interior of the tower but exposed to contact with water
- Blue Marsh Dam
    - Reconstruct internal filter drain system - $ 8 million (USACE Philadelphia District 2010)
        - The O'Brien & Gere team estimate is similar at $8.7 million FY2013
        - Additional investigations and studies need to be conducted to verify the feasibility of the proposed method for reconstruction of the internal filter drain system. The proposed method would only be feasible if the reservoir pool is significantly drawn down.

The only additional replacement cost identified by the O'Brien & Gere team was for the potential construction of toe drains at both Beltzville and Blue Marsh Dams. At the current time, no information is available to evaluate the effectiveness of the internal filter drains at either dam site. If seepage and potential piping of fine-grained materials are ongoing concerns, installation of a toe drain system would be a reasonable measure to control seepage in advance of replacement of the internal filter drain system. . For Beltzville Dam, the estimated cost in FY 2013 is $3.9 million; for Blue Marsh Dam, the estimated cost in FY 2013 is $1.3 million.

The only interim replacement item identified was the addition of five piezometers at Beltzville Dam to enhance the monitoring network. The estimated cost is $50,000 FY2013 and is noted under the major repairs/upgrades costs tables, since USACE would likely place it in that category

Major repairs/upgrades costs (capital, operating and maintenance costs) to support the Beltzville and Blue Marsh Reservoirs dam infrastructure needs were estimated in FY 2013 dollars. The projected time periods for implementation over the next 30 years were identified. The basis for the inclusion/exclusion of work item costs, the source for cost data related to each category of cost, and the estimated costs to be included for these time periods were reviewed and confirmed with USACE.

# TABLES

| Table 2-1 Beltzville Dam Estimated Annual Operation & Maintenance Costs | | | | | | |
|---|---|---|---|---|---|---|
| | Low Projection | | | High Projection | | |
| FY | Projected O&M | Cost Share | DRBC Cost | Projected O&M | Cost Share | DRBC Cost |
| | | Escalation Rate = | 3.20% | | Escalation Rate = | 4.50% |
| 2012 | $1,200,000 | | | $1,200,000 | | |
| 2013 | $1,238,400 | 31.01% | $384,028 | $1,254,000 | 31.01% | $388,865 |
| 2014 | $1,278,029 | 31.01% | $396,317 | $1,310,430 | 31.01% | $406,364 |
| 2015 | $1,318,926 | 31.01% | $408,999 | $1,369,399 | 31.01% | $424,651 |
| 2016 | $1,361,131 | 31.01% | $422,087 | $1,431,022 | 31.01% | $443,760 |
| 2017 | $1,404,688 | 31.01% | $435,594 | $1,495,418 | 31.01% | $463,729 |
| 2018 | $1,449,638 | 31.01% | $449,533 | $1,562,712 | 31.01% | $484,597 |
| 2019 | $1,496,026 | 31.01% | $463,918 | $1,633,034 | 31.01% | $506,404 |
| 2020 | $1,543,899 | 31.01% | $478,763 | $1,706,521 | 31.01% | $529,192 |
| 2021 | $1,593,304 | 31.01% | $494,083 | $1,783,314 | 31.01% | $553,006 |
| 2022 | $1,644,289 | 31.01% | $509,894 | $1,863,563 | 31.01% | $577,891 |
| 2023 | $1,696,907 | 31.01% | $526,211 | $1,947,424 | 31.01% | $603,896 |
| 2024 | $1,751,208 | 31.01% | $543,049 | $2,035,058 | 31.01% | $631,071 |
| 2025 | $1,807,246 | 31.01% | $560,427 | $2,126,635 | 31.01% | $659,470 |
| 2026 | $1,865,078 | 31.01% | $578,361 | $2,222,334 | 31.01% | $689,146 |
| 2027 | $1,924,761 | 31.01% | $596,868 | $2,322,339 | 31.01% | $720,157 |
| 2028 | $1,986,353 | 31.01% | $615,968 | $2,426,844 | 31.01% | $752,564 |
| 2029 | $2,049,916 | 31.01% | $635,679 | $2,536,052 | 31.01% | $786,430 |
| 2030 | $2,115,513 | 31.01% | $656,021 | $2,650,175 | 31.01% | $821,819 |
| 2031 | $2,183,210 | 31.01% | $677,013 | $2,769,432 | 31.01% | $858,801 |
| 2032 | $2,253,073 | 31.01% | $698,678 | $2,894,057 | 31.01% | $897,447 |
| 2033 | $2,325,171 | 31.01% | $721,036 | $3,024,289 | 31.01% | $937,832 |
| 2034 | $2,399,576 | 31.01% | $744,109 | $3,160,382 | 31.01% | $980,035 |
| 2035 | $2,476,363 | 31.01% | $767,920 | $3,302,600 | 31.01% | $1,024,136 |
| 2036 | $2,555,606 | 31.01% | $792,494 | $3,451,217 | 31.01% | $1,070,222 |
| 2037 | $2,637,386 | 31.01% | $817,853 | $3,606,521 | 31.01% | $1,118,382 |
| 2038 | $2,721,782 | 31.01% | $844,025 | $3,768,815 | 31.01% | $1,168,709 |
| 2039 | $2,808,879 | 31.01% | $871,033 | $3,938,411 | 31.01% | $1,221,301 |
| 2040 | $2,898,763 | 31.01% | $898,907 | $4,115,640 | 31.01% | $1,276,260 |
| 2041 | $2,991,524 | 31.01% | $927,672 | $4,300,844 | 31.01% | $1,333,692 |
| 2042 | $3,087,253 | 31.01% | $957,357 | $4,494,382 | 31.01% | $1,393,708 |
| 2043 | $3,186,045 | 31.01% | $987,992 | $4,696,629 | 31.01% | $1,456,425 |
| 2044 | $3,287,998 | 31.01% | $1,019,608 | $4,907,977 | 31.01% | $1,521,964 |

Notes:
1. Cost Share percentage based on USA/DRBC 1966/1980 Contracts
2. Low Escalation Rate based on ENR Construction Cost Index 1982 to 2012
3. High Escalation Rate based on ENR Construction Cost Index 1926 to 2012

| Table 2-2 Blue Marsh Dam Estimated Annual Operation & Maintenance Costs | | | | | | |
|---|---|---|---|---|---|---|
| | Low Projection | | | High Projection | | |
| FY | Projected O&M | Cost Share | DRBC Cost | Projected O&M | Cost Share | DRBC Cost |
| | | Escalation Rate = | 3.20% | | Escalation Rate = | 4.50% |
| 2012 | $800,000 | | | $800,000 | | |
| 2013 | $825,600 | 25.397% | $209,678 | $836,000 | 25.397% | $212,319 |
| 2014 | $852,019 | 25.397% | $216,387 | $873,620 | 25.397% | $221,873 |
| 2015 | $879,284 | 25.397% | $223,312 | $912,933 | 25.397% | $231,858 |
| 2016 | $907,421 | 25.397% | $230,458 | $954,015 | 25.397% | $242,291 |
| 2017 | $936,458 | 25.397% | $237,832 | $996,946 | 25.397% | $253,194 |
| 2018 | $966,425 | 25.397% | $245,443 | $1,041,808 | 25.397% | $264,588 |
| 2019 | $997,351 | 25.397% | $253,297 | $1,088,689 | 25.397% | $276,494 |
| 2020 | $1,029,266 | 25.397% | $261,403 | $1,137,680 | 25.397% | $288,937 |
| 2021 | $1,062,202 | 25.397% | $269,768 | $1,188,876 | 25.397% | $301,939 |
| 2022 | $1,096,193 | 25.397% | $278,400 | $1,242,376 | 25.397% | $315,526 |
| 2023 | $1,131,271 | 25.397% | $287,309 | $1,298,282 | 25.397% | $329,725 |
| 2024 | $1,167,472 | 25.397% | $296,503 | $1,356,705 | 25.397% | $344,562 |
| 2025 | $1,204,831 | 25.397% | $305,991 | $1,417,757 | 25.397% | $360,068 |
| 2026 | $1,243,385 | 25.397% | $315,783 | $1,481,556 | 25.397% | $376,271 |
| 2027 | $1,283,174 | 25.397% | $325,888 | $1,548,226 | 25.397% | $393,203 |
| 2028 | $1,324,235 | 25.397% | $336,316 | $1,617,896 | 25.397% | $410,897 |
| 2029 | $1,366,611 | 25.397% | $347,078 | $1,690,701 | 25.397% | $429,387 |
| 2030 | $1,410,342 | 25.397% | $358,185 | $1,766,783 | 25.397% | $448,710 |
| 2031 | $1,455,473 | 25.397% | $369,647 | $1,846,288 | 25.397% | $468,902 |
| 2032 | $1,502,048 | 25.397% | $381,475 | $1,929,371 | 25.397% | $490,002 |
| 2033 | $1,550,114 | 25.397% | $393,682 | $2,016,193 | 25.397% | $512,053 |
| 2034 | $1,599,718 | 25.397% | $406,280 | $2,106,922 | 25.397% | $535,095 |
| 2035 | $1,650,909 | 25.397% | $419,281 | $2,201,733 | 25.397% | $559,174 |
| 2036 | $1,703,738 | 25.397% | $432,698 | $2,300,811 | 25.397% | $584,337 |
| 2037 | $1,758,257 | 25.397% | $446,545 | $2,404,348 | 25.397% | $610,632 |
| 2038 | $1,814,521 | 25.397% | $460,834 | $2,512,543 | 25.397% | $638,111 |
| 2039 | $1,872,586 | 25.397% | $475,581 | $2,625,608 | 25.397% | $666,826 |
| 2040 | $1,932,509 | 25.397% | $490,799 | $2,743,760 | 25.397% | $696,833 |
| 2041 | $1,994,349 | 25.397% | $506,505 | $2,867,229 | 25.397% | $728,190 |
| 2042 | $2,058,168 | 25.397% | $522,713 | $2,996,255 | 25.397% | $760,959 |
| 2043 | $2,124,030 | 25.397% | $539,440 | $3,131,086 | 25.397% | $795,202 |
| 2044 | $2,191,999 | 25.397% | $556,702 | $3,271,985 | 25.397% | $830,986 |

Notes:
1. Cost Share Percentage based on USA/ DRBC 1971 Contract. Cost Share percentage increased from 12.698 % to 25.397 % based on first use for water supply purposes has occurred.
2. Low Escalation Rate based on ENR Construction Cost Index 1982 to 2012
3. High Escalation Rate based on ENR Construction Cost Index 1926 to 2012

**Table 2-3 Beltzville Dam Estimated Major Repairs/ Upgrades Costs - Low Projection**

| FY | Description | FY 13 Est. Cost | Escalate to FY Cost | Cost Share % | DRBC Est. Cost |
|---|---|---|---|---|---|
| | Escalation Rate (Low Projection) = | 3.200% | | | |
| 2013 | Electrical upgrade @ elevations 548, 530 & 519 | $50,000 | $50,000 | 31.01% | $15,505 |
| 2013 | Replace Operations Building HVAC | $30,000 | $30,000 | 31.01% | $9,303 |
| 2013 | Rehabilitate Flood Control Gate | $455,000 | $455,000 | 0.00% | $0 |
| 2013 | Repair Stilling Basin Slab | $375,000 | $375,000 | 31.01% | $116,288 |
| 2013 | Periodic Assessment/ Potential Failure Mode Analysis (PFMA) | $70,000 | $70,000 | 31.01% | $21,707 |
| 2014 | Upgrade Operation Building Potable Water System | $25,000 | $25,800 | 0.00% | $0 |
| 2015 | GIS Mapping Database | $110,000 | $117,153 | 31.01% | $36,329 |
| 2015 | Piezometers (5) Installation - O'Brien & Gere Recommendation | $50,000 | $53,251 | 31.01% | $16,513 |
| 2015 | Elevator Upgrade | $500,000 | $532,512 | 31.01% | $165,132 |
| 2015 | Replace Sump Pit 4" Backwater Valve | $50,000 | $53,251 | 31.01% | $16,513 |
| 2015 | Repair Emergency Spillway Chute | $473,000 | $503,756 | 31.01% | $156,215 |
| 2015 | Tower Mech. Repairs (Intake/Exhaust Fans/ Heaters) | $40,000 | $42,601 | 31.01% | $13,211 |
| 2015 | Replace gear box & limit torque motor on water quality gate | $50,000 | $53,251 | 31.01% | $16,513 |
| 2015 | A-E Study on Tower Concrete | $50,000 | $53,251 | 31.01% | $16,513 |
| 2016 | Intermediate Inspection | $30,000 | $32,973 | 31.01% | $10,225 |
| 2017 | Positional Survey: Dams & Structures (every 5 yrs) | $52,000 | $58,982 | 31.01% | $18,290 |
| 2017 | Plug/Grout Piezometer/H20 Sampling Piping Terminals | $210,000 | $238,198 | 31.01% | $73,865 |
| 2017 | Underwater, Bridge, Hyd. Steel Struct. Inspections/Sed. Mapping | $200,000 | $226,855 | 31.01% | $70,348 |
| 2018 | Replace Hydraulic fluid tank, pumps (2), motors (2) | $250,000 | $292,643 | 31.01% | $90,749 |
| 2018 | Rehab Water Quality Gate | $455,000 | $532,611 | 31.01% | $165,163 |
| 2018 | Periodic Inspection | $30,000 | $35,117 | 31.01% | $10,890 |
| 2019 | Automated Geotechnical Data Acquisition System | $215,000 | $259,727 | 31.01% | $80,541 |
| 2019 | Install AAR Remedial Lining @ Intake Tower - See Major Replacement | $0 | $0 | 31.01% | $0 |
| 2021 | Intermediate Inspection | $30,000 | $38,597 | 31.01% | $11,969 |
| 2021 | Paint Spillway/ Tower Bridges | $544,000 | $699,901 | 31.01% | $217,039 |
| 2022 | Underwater, Bridge, Hyd. Steel Struct. Inspections/Sed. Mapping | $200,000 | $265,551 | 31.01% | $82,347 |
| 2022 | Positional Survey: Dams & Structures (every 5 yrs) | $52,000 | $69,043 | 31.01% | $21,410 |
| 2023 | Rehab Service Gate | $455,000 | $623,460 | 31.01% | $193,335 |
| 2023 | Periodic Assessment | $70,000 | $95,917 | 31.01% | $29,744 |
| 2026 | Intermediate Inspection | $30,000 | $45,181 | 31.01% | $14,011 |
| 2027 | Underwater, Bridge, Hyd. Steel Struct. Inspections/Sed. Mapping | $200,000 | $310,846 | 31.01% | $96,393 |
| 2027 | Positional Survey: Dams & Structures (every 5 yrs) | $52,000 | $80,820 | 31.01% | $25,062 |
| 2028 | Rehab Service Gate | $455,000 | $729,805 | 31.01% | $226,313 |
| 2028 | Periodic Inspection | $30,000 | $48,119 | 31.01% | $14,922 |
| 2031 | Intermediate Inspection | $30,000 | $52,888 | 31.01% | $16,401 |
| 2031 | Paint Spillway/ Tower Bridges | $544,000 | $959,033 | 31.01% | $297,396 |
| 2032 | Underwater, Bridge, Hyd. Steel Struct. Inspections/Sed. Mapping | $200,000 | $363,868 | 31.01% | $112,836 |
| 2032 | Positional Survey: Dams & Structures (every 5 yrs) | $52,000 | $94,606 | 31.01% | $29,337 |
| 2033 | Rehab Flood Control Gate | $455,000 | $854,290 | 0.00% | $0 |
| 2033 | Periodic Assessment | $70,000 | $131,429 | 31.01% | $40,756 |
| 2033 | Issue Evaluation Study (IES) - Risk Management Center | $70,000 | $131,429 | 0% | $0 |
| 2036 | Intermediate Inspection | $30,000 | $61,909 | 31.01% | $19,198 |
| 2037 | Underwater, Bridge, Hyd. Steel Struct. Inspections/Sed. Mapping | $200,000 | $425,934 | 31.01% | $132,082 |
| 2037 | Positional Survey: Dams & Structures (every 5 yrs) | $52,000 | $110,743 | 31.01% | $34,341 |
| 2038 | Rehab Water Quality Gate | $455,000 | $1,000,009 | 31.01% | $310,103 |
| 2038 | Periodic Inspection | $30,000 | $65,935 | 31.01% | $20,446 |
| 2041 | Intermediate Inspection | $30,000 | $72,469 | 31.01% | $22,473 |
| 2041 | Paint Spillway/ Tower Bridges | $544,000 | $1,314,106 | 31.01% | $407,504 |
| 2042 | Underwater, Bridge, Hyd. Steel Struct. Inspections/Sed. Mapping | $200,000 | $498,587 | 31.01% | $154,612 |
| 2042 | Positional Survey: Dams & Structures (every 5 yrs) | $52,000 | $129,633 | 31.01% | $40,199 |
| 2043 | Rehab Service Gate | $455,000 | $1,170,583 | 31.01% | $362,998 |
| 2043 | Periodic Assessment | $70,000 | $180,090 | 31.01% | $55,846 |
| | **TOTAL** | $9,427,000 | $14,716,715 | | $4,108,886 |

Notes:
1. Cost Share percentage based on USA/DRBC 1966/ 1980 Contracts
2. Low Escalation Rate based on ENR Construction Cost Index 1982 to 2012
3. Level of Contingency on USACE Cost Estimates not identified

**Table 2-3 Beltzville Dam Estimated Major Repairs/ Upgrades Costs - Low Projection**

**Table 2-4 Beltzville Dam Estimated Major Repairs/ Upgrades Costs - High Projection**

| FY | Description | FY 13 Est. Cost | Escalate to FY Cost | Cost Share | DRBC Est. Cost |
|---|---|---|---|---|---|
| | Escalation Rate (High Projection) = | 4.50% | | | |
| 2013 | Electrical upgrade @ elevations 548, 530 & 519 | $50,000 | $50,000 | 31.01% | $15,505 |
| 2013 | Replace Operations Building HVAC | $30,000 | $30,000 | 31.01% | $9,303 |
| 2013 | Rehabilitate Flood Control Gate | $455,000 | $455,000 | 0.00% | $0 |
| 2013 | Repair Stilling Basin Slab | $375,000 | $375,000 | 31.01% | $116,288 |
| 2013 | Periodic Assessment/ Potential Failure Mode Analysis (PFMA) | $70,000 | $70,000 | 31.01% | $21,707 |
| 2014 | Upgrade Operation Building Potable Water System | $25,000 | $26,125 | 0.00% | $0 |
| 2015 | GIS Mapping Database | $110,000 | $120,123 | 31.01% | $37,250 |
| 2015 | Piezometers (5) Installation - O'Brien & Gere Recommendation | $50,000 | $54,601 | 31.01% | $16,932 |
| 2015 | Elevator Upgrade | $500,000 | $546,013 | 31.01% | $169,318 |
| 2015 | Replace Sump Pit 4" Backwater Valve | $50,000 | $54,601 | 31.01% | $16,932 |
| 2015 | Repair Emergency Spillway Chute | $473,000 | $516,528 | 31.01% | $160,175 |
| 2015 | Tower Mech. Repairs (Intake/Exhaust Fans/ Heaters) | $40,000 | $43,681 | 31.01% | $13,545 |
| 2015 | Replace gear box & limit torque motor on water quality gate | $50,000 | $54,601 | 31.01% | $16,932 |
| 2015 | A-E Study on Tower Concrete | $50,000 | $54,601 | 31.01% | $16,932 |
| 2016 | Intermediate Inspection | $30,000 | $34,235 | 31.01% | $10,616 |
| 2017 | Positional Survey: Dams & Structures (every 5 yrs) | $52,000 | $62,011 | 31.01% | $19,230 |
| 2017 | Plug/Grout Piezometer/H20 Sampling Piping Terminals | $210,000 | $250,429 | 31.01% | $77,658 |
| 2017 | Underwater, Bridge, Hyd. Steel Struct. Inspections/Sed. Mapping | $200,000 | $238,504 | 31.01% | $73,960 |
| 2018 | Replace Hydraulic fluid tank, pumps (2), motors (2) | $250,000 | $311,545 | 31.01% | $96,610 |
| 2018 | Rehab Water Quality Gate | $455,000 | $567,013 | 31.01% | $175,831 |
| 2018 | Periodic Inspection | $30,000 | $37,385 | 31.01% | $11,593 |
| 2019 | Automated Geotechnical Data Acquisition System | $215,000 | $279,986 | 31.01% | $86,824 |
| 2019 | Install AAR Remedial Lining @ Intake Tower - See Major Replacement | $0 | $0 | 31.01% | $0 |
| 2021 | Intermediate Inspection | $30,000 | $42,663 | 31.01% | $13,230 |
| 2021 | Paint Spillway/ Tower Bridges | $544,000 | $773,623 | 31.01% | $239,900 |
| 2022 | Underwater, Bridge, Hyd. Steel Struct. Inspections/Sed. Mapping | $200,000 | $297,219 | 31.01% | $92,168 |
| 2022 | Positional Survey: Dams & Structures (every 5 yrs) | $52,000 | $77,277 | 31.01% | $23,964 |
| 2023 | Rehab Service Gate | $455,000 | $706,601 | 31.01% | $219,117 |
| 2023 | Periodic Assessment | $70,000 | $108,708 | 31.01% | $33,710 |
| 2026 | Intermediate Inspection | $30,000 | $53,166 | 31.01% | $16,487 |
| 2027 | Underwater, Bridge, Hyd. Steel Struct. Inspections/Sed. Mapping | $200,000 | $370,389 | 31.01% | $114,858 |
| 2027 | Positional Survey: Dams & Structures (every 5 yrs) | $52,000 | $96,301 | 31.01% | $29,863 |
| 2028 | Rehab Service Gate | $455,000 | $880,554 | 31.01% | $273,060 |
| 2028 | Periodic Inspection | $30,000 | $58,058 | 31.01% | $18,004 |
| 2031 | Intermediate Inspection | $30,000 | $66,254 | 31.01% | $20,545 |
| 2031 | Paint Spillway/ Tower Bridges | $544,000 | $1,201,412 | 31.01% | $372,558 |
| 2032 | Underwater, Bridge, Hyd. Steel Struct. Inspections/Sed. Mapping | $200,000 | $461,572 | 31.01% | $143,133 |
| 2032 | Positional Survey: Dams & Structures (every 5 yrs) | $52,000 | $120,009 | 31.01% | $37,215 |
| 2033 | Rehab Flood Control Gate | $455,000 | $1,097,330 | 0.00% | $0 |
| 2033 | Periodic Assessment | $70,000 | $168,820 | 31.01% | $52,351 |
| 2033 | Issue Evaluation Study (IES) - Risk Management Center | $70,000 | $168,820 | 0% | $0 |
| 2036 | Intermediate Inspection | $30,000 | $82,565 | 31.01% | $25,603 |
| 2037 | Underwater, Bridge, Hyd. Steel Struct. Inspections/Sed. Mapping | $200,000 | $575,203 | 31.01% | $178,370 |
| 2037 | Positional Survey: Dams & Structures (every 5 yrs) | $52,000 | $149,553 | 31.01% | $46,376 |
| 2038 | Rehab Water Quality Gate | $455,000 | $1,367,473 | 31.01% | $424,053 |
| 2038 | Periodic Inspection | $30,000 | $90,163 | 31.01% | $27,960 |
| 2041 | Intermediate Inspection | $30,000 | $102,891 | 31.01% | $31,906 |
| 2041 | Paint Spillway/ Tower Bridges | $544,000 | $1,865,757 | 31.01% | $578,571 |
| 2042 | Underwater, Bridge, Hyd. Steel Struct. Inspections/Sed. Mapping | $200,000 | $716,807 | 31.01% | $222,282 |
| 2042 | Positional Survey: Dams & Structures (every 5 yrs) | $52,000 | $186,370 | 31.01% | $57,793 |
| 2043 | Rehab Service Gate | $455,000 | $1,704,120 | 31.01% | $528,448 |
| 2043 | Periodic Assessment | $70,000 | $262,172 | 31.01% | $81,300 |
| | **TOTAL** | $9,427,000 | $18,083,832 | | $5,065,966 |

Notes:
1. Cost Share percentage based on USA/DRBC 1966/1980 Contracts
2. High Escalation Rate based on ENR Construction Cost Index 1926 to 2012
3. Level of Contingency on USACE Cost Estimates not identified

**Table 2-4 Beltzville Dam Estimated Major Repairs/ Upgrades Costs - High Projection**

**Table 2-5 Blue Marsh Dam Estimated Major Repairs/ Upgrades Costs - Low Projection**

| FY | Description | FY 13 Est. Cost | Escalate to FY Cost | Cost Share % | DRBC Est. Cost |
|---|---|---|---|---|---|
| | Escalation Rate (Low Projection) = | 3.20% | | | |
| 2013 | Replace Leaf Gate on Service Gate #1/Motor | $300,000 | $300,000 | 25.397% | $76,191 |
| 2013 | Lead Paint Encapsulation - Tower | $200,000 | $200,000 | 25.397% | $50,794 |
| 2013 | Lead Paint Remediation - Service Bridge | $290,000 | $290,000 | 25.397% | $73,651 |
| 2014 | Periodic Assessment/ Potential Failure Mode Analysis (PFMA) | $70,000 | $72,240 | 25.397% | $18,347 |
| 2014 | Rehab Bulkheads | $250,000 | $258,000 | 25.397% | $65,524 |
| 2014 | Automated Geotechnical Data Acquisition System | $265,000 | $273,480 | 25.397% | $69,456 |
| 2014 | Rehab Water Quality Gate | $600,000 | $619,200 | 25.397% | $157,258 |
| 2015 | GIS Mapping Database | $110,000 | $117,153 | 25.397% | $29,753 |
| 2016 | Replace Operations Building Roof | $50,000 | $54,955 | 0% | $0 |
| 2016 | Rehabilitate Flood Control Gate | $500,000 | $549,552 | 0% | $0 |
| 2017 | Intermediate Inspection | $30,000 | $34,028 | 25.397% | $8,642 |
| 2017 | Positional Survey: Dams & Structures (every 5 yrs) | $52,000 | $58,982 | 25.397% | $14,980 |
| 2017 | Underwater, Bridge, Hyd. Steel Struct. Inspections/Sed. Mapping | $200,000 | $226,855 | 25.397% | $57,614 |
| 2019 | Periodic Inspection | $30,000 | $36,241 | 25.397% | $9,204 |
| 2020 | Water Control Selective Withdrawal System | $1,500,000 | $1,870,032 | 25.397% | $474,932 |
| 2021 | Rehab Service Gate | $500,000 | $643,291 | 25.397% | $163,377 |
| 2022 | Intermediate Inspection | $30,000 | $39,833 | 25.397% | $10,116 |
| 2022 | Positional Survey: Dams & Structures (every 5 yrs) | $52,000 | $69,043 | 25.397% | $17,535 |
| 2022 | Underwater, Bridge, Hyd. Steel Struct. Inspections | $200,000 | $265,551 | 25.397% | $67,442 |
| 2024 | Periodic Assessment | $70,000 | $98,986 | 25.397% | $25,140 |
| 2026 | Rehab Service Gate | $500,000 | $753,019 | 25.397% | $191,244 |
| 2027 | Intermediate Inspection | $30,000 | $46,627 | 25.397% | $11,842 |
| 2027 | Positional Survey: Dams & Structures (every 5 yrs) | $52,000 | $80,820 | 25.397% | $20,526 |
| 2027 | Underwater, Bridge, Hyd. Steel Struct. Inspections/Sed. Mapping | $200,000 | $310,846 | 25.397% | $78,946 |
| 2029 | Periodic Inspection | $30,000 | $49,659 | 25.397% | $12,612 |
| 2032 | Intermediate Inspection | $30,000 | $54,580 | 25.397% | $13,862 |
| 2032 | Positional Survey: Dams & Structures (every 5 yrs) | $52,000 | $94,606 | 25.397% | $24,027 |
| 2032 | Underwater, Bridge, Hyd. Steel Struct. Inspections/Sed. Mapping | $200,000 | $363,868 | 25.397% | $92,412 |
| 2033 | Issue Evaluation Study (IES) - Risk Management Center | $70,000 | $131,429 | 0% | $0 |
| 2034 | Periodic Assessment | $70,000 | $135,635 | 25.397% | $34,447 |
| 2034 | Rehab Water Quality Gate | $600,000 | $1,162,585 | 25.397% | $295,262 |
| 2036 | Rehabilitate Flood Control Gate | $500,000 | $1,031,818 | 0% | $0 |
| 2037 | Intermediate Inspection | $30,000 | $63,890 | 25.397% | $16,226 |
| 2037 | Positional Survey: Dams & Structures (every 5 yrs) | $52,000 | $110,743 | 25.397% | $28,125 |
| 2037 | Underwater, Bridge, Hyd. Steel Struct. Inspections/Sed. Mapping | $200,000 | $425,934 | 25.397% | $108,175 |
| 2039 | Periodic Inspection | $30,000 | $68,045 | 25.397% | $17,281 |
| 2041 | Rehab Service Gate | $500,000 | $1,207,818 | 25.397% | $306,750 |
| 2042 | Intermediate Inspection | $30,000 | $74,788 | 25.397% | $18,994 |
| 2042 | Positional Survey: Dams & Structures (every 5 yrs) | $52,000 | $129,633 | 25.397% | $32,923 |
| 2042 | Underwater, Bridge, Hyd. Steel Struct. Inspections/Sed. Mapping | $200,000 | $498,587 | 25.397% | $126,626 |
| 2044 | Periodic Assessment | $70,000 | $185,853 | 25.397% | $47,201 |
| | | | | | |
| | **Bernville Protective Works** | | | | |
| 2011 | Upgrade Pumping Station Float Switch System | $0 | $0 | 0% | $0 |
| 2012 | Replace Roof on Pumping Station | $0 | $0 | 0% | $0 |
| 2015 | Upgrade Pumping Station Control System | $0 | $0 | 0% | $0 |
| 2025 | Rehabilitate Pumping Station Pumps | $0 | $0 | 0% | $0 |
| | **TOTAL** | $8,797,000 | $13,058,207 | | $2,867,436 |

Notes:
1. Cost Share percentage based on USA/ DRBC 1971 Contract. Cost Share percentage increased from 12.698 % to 25.397 % based on first use for water supply purposes has occurred.
2.Low Escalation Rate based on ENR Construction Cost Index 1982 to 2012
3. Level of Contingency on USACE Cost Estimates not identified

**Table 2-5 Blue Marsh Dam Estimated Major Repairs/ Upgrades Costs - Low Projection**

**Table 2-6 Blue Marsh Dam Estimated Major Repairs/ Upgrades Costs - High Projection**

| FY | Description | FY 13 Est. Cost | Escalate to FY Cost | Cost Share % | DRBC Est. Cost |
|---|---|---|---|---|---|
| | Escalation Rate (High Projection) = | 4.50% | | | |
| 2013 | Replace Leaf Gate on Service Gate #1/Motor | $300,000 | $300,000 | 25.397% | $76,191 |
| 2013 | Lead Paint Encapsulation - Tower | $200,000 | $200,000 | 25.397% | $50,794 |
| 2013 | Lead Paint Remediation - Service Bridge | $290,000 | $290,000 | 25.397% | $73,651 |
| 2014 | Periodic Assessment/ Potential Failure Mode Analysis (PFMA) | $70,000 | $73,150 | 25.397% | $18,578 |
| 2014 | Rehab Bulkheads | $250,000 | $261,250 | 25.397% | $66,350 |
| 2014 | Automated Geotechnical Data Acquisition System | $265,000 | $276,925 | 25.397% | $70,331 |
| 2014 | Rehab Water Quality Gate | $600,000 | $627,000 | 25.397% | $159,239 |
| 2015 | GIS Mapping Database | $110,000 | $120,123 | 25.397% | $30,508 |
| 2016 | Replace Operations Building Roof | $50,000 | $57,058 | 0% | $0 |
| 2016 | Rehabilitate Flood Control Gate | $500,000 | $570,583 | 0% | $0 |
| 2017 | Intermediate Inspection | $30,000 | $35,776 | 25.397% | $9,086 |
| 2017 | Positional Survey: Dams & Structures (every 5 yrs) | $52,000 | $62,011 | 25.397% | $15,749 |
| 2017 | Underwater, Bridge, Hyd. Steel Struct. Inspections/Sed. Mapping | $200,000 | $238,504 | 25.397% | $60,573 |
| 2019 | Periodic Inspection | $30,000 | $39,068 | 25.397% | $9,922 |
| 2020 | Water Control Selective Withdrawal System | $1,500,000 | $2,041,293 | 25.397% | $518,427 |
| 2021 | Rehab Service Gate | $500,000 | $711,050 | 25.397% | $180,585 |
| 2022 | Intermediate Inspection | $30,000 | $44,583 | 25.397% | $11,323 |
| 2022 | Positional Survey: Dams & Structures (every 5 yrs) | $52,000 | $77,277 | 25.397% | $19,626 |
| 2022 | Underwater, Bridge, Hyd. Steel Struct. Inspections | $200,000 | $297,219 | 25.397% | $75,485 |
| 2024 | Periodic Assessment | $70,000 | $113,600 | 25.397% | $28,851 |
| 2026 | Rehab Service Gate | $500,000 | $886,098 | 25.397% | $225,042 |
| 2027 | Intermediate Inspection | $30,000 | $55,558 | 25.397% | $14,110 |
| 2027 | Positional Survey: Dams & Structures (every 5 yrs) | $52,000 | $96,301 | 25.397% | $24,458 |
| 2027 | Underwater, Bridge, Hyd. Steel Struct. Inspections/Sed. Mapping | $200,000 | $370,389 | 25.397% | $94,068 |
| 2029 | Periodic Inspection | $30,000 | $60,671 | 25.397% | $15,409 |
| 2032 | Intermediate Inspection | $30,000 | $69,236 | 25.397% | $17,584 |
| 2032 | Positional Survey: Dams & Structures (every 5 yrs) | $52,000 | $120,009 | 25.397% | $30,479 |
| 2032 | Underwater, Bridge, Hyd. Steel Struct. Inspections/Sed. Mapping | $200,000 | $461,572 | 25.397% | $117,225 |
| 2033 | Issue Evaluation Study (IES) - Risk Management Center | $70,000 | $168,820 | 0% | $0 |
| 2034 | Periodic Assessment | $70,000 | $176,417 | 25.397% | $44,805 |
| 2034 | Rehab Water Quality Gate | $600,000 | $1,512,145 | 25.397% | $384,039 |
| 2036 | Rehabilitate Flood Control Gate | $500,000 | $1,376,083 | 0% | $0 |
| 2037 | Intermediate Inspection | $30,000 | $86,280 | 25.397% | $21,913 |
| 2037 | Positional Survey: Dams & Structures (every 5 yrs) | $52,000 | $149,553 | 25.397% | $37,982 |
| 2037 | Underwater, Bridge, Hyd. Steel Struct. Inspections/Sed. Mapping | $200,000 | $575,203 | 25.397% | $146,084 |
| 2039 | Periodic Inspection | $30,000 | $94,220 | 25.397% | $23,929 |
| 2041 | Rehab Service Gate | $500,000 | $1,714,850 | 25.397% | $435,520 |
| 2042 | Intermediate Inspection | $30,000 | $107,521 | 25.397% | $27,307 |
| 2042 | Positional Survey: Dams & Structures (every 5 yrs) | $52,000 | $186,370 | 25.397% | $47,332 |
| 2042 | Underwater, Bridge, Hyd. Steel Struct. Inspections/Sed. Mapping | $200,000 | $716,807 | 25.397% | $182,048 |
| 2044 | Periodic Assessment | $70,000 | $273,970 | 25.397% | $69,580 |
| | | | | | |
| | **Bernville Protective Works** | | | | |
| 2011 | Upgrade Pumping Station Float Switch System | $0 | $0 | 0% | $0 |
| 2012 | Replace Roof on Pumping Station | $0 | $0 | 0% | $0 |
| 2015 | Upgrade Pumping Station Control System | $0 | $0 | 0% | $0 |
| 2025 | Rehabilitate Pumping Station Pumps | $0 | $0 | 0% | $0 |
| | **TOTAL** | $8,797,000 | $15,694,542 | | $3,434,182 |

Notes:
1. Cost Share percentage based on USA/ DRBC 1971 Contract. Cost Share percentage increased from 12.698 % to 25.397 % based on first use for water supply purposes has occurred.
2.High Escalation Rate based on ENR Construction Cost Index 1926 to 2012
3. Level of Contingency on USACE Cost Estimates not identified

**Table 2-6 Blue Marsh Dam Estimated Major Repairs/ Upgrades Costs - High Projection**

| Table 2-7 Beltzville/ Blue Marsh Dams Estimated Major Capital Replacement Cost Programs - Low Projection | | | | | | |
|---|---|---|---|---|---|---|
| **FY** | **Description** | **FY 13 Est. Cost** | **Escalate to FY Cost** | **Cost Share %** | **DRBC Est. Cost** | **USACE Cost Estimate (2010)** |
| | Escalation Rate (Low Projection)= | 3.20% | | | | |
| **Blue Marsh Dam** | | | | | | |
| 2020 | Toe Drain | $1,300,000 | $1,620,695 | 11.765% | $190,675 | Not Considered |
| 2043 | Filter Relocation - USACE Rehabilitation Method (1) | $8,700,000 | $22,382,581 | 11.765% | $2,633,311 | $8,000,000 |
| | **TOTAL** | $10,000,000 | $24,003,276 | | $2,823,985 | |
| **Beltzville Dam** | | | | | | |
| 2019 | CARPI Geomembrane System - Intake Tower (2) | $5,500,000 | $6,644,172 | 30.980% | $2,058,365 | CARPI Quote (2006) with Exclusions |
| 2020 | Toe Drain | $3,900,000 | $4,862,084 | 30.980% | $1,506,274 | Not Considered |
| 2043 | Filter Relocation/ Grout Curtain - USACE Rehabilitation Method (1) | $36,000,000 | $92,617,578 | 30.980% | $28,692,926 | $18,000,000 |
| | **TOTAL** | $45,400,000 | $104,123,834 | | $32,257,564 | |

Notes:
1. USACE Methodology to Support Clay Core during Construction not defined. Cost excluded from Estimated Cost
2. CARPI Cost Estimate extended to include application of elastomeric coating system to waterproof Water Quality Control Wells
3. Cost Share based on Major Capital Replacement in USA/DRBC Contract
4. Carpi Quotation to USACE March 2, 2006 for $1,400,943 with Exclusions

| Table 2-8 Beltzville/ Blue Marsh Dams Major Capital Replacement Cost Programs - High Projection | | | | | | |
|---|---|---|---|---|---|---|
| **FY** | **Description** | **FY 13 Est. Cost** | **Escalate to FY Cost** | **Cost Share %** | **DRBC Est. Cost** | **USACE Cost Estimate (2010)** |
| | Escalation Rate (High Projection)= | 4.50% | | | | |
| **Blue Marsh Dam** | | | | | | |
| 2020 | Toe Drain | $1,300,000 | $1,769,120 | 11.765% | $208,137 | Not Considered |
| 2043 | Filter Relocation - USACE Rehabilitation Method (1) | $8,700,000 | $32,584,268 | 11.765% | $3,833,539 | $8,000,000 |
| | **TOTAL** | $10,000,000 | $34,353,388 | | $4,041,676 | |
| **Beltzville Dam** | | | | | | |
| 2019 | CARPI Geomembrane System - Intake Tower (2) | $5,500,000 | $7,162,431 | 30.980% | $2,218,921 | CARPI Quote (2006) with Exclusions |
| 2020 | Toe Drain | $3,900,000 | $5,307,361 | 30.980% | $1,644,220 | Not Considered |
| 2043 | Filter Relocation/ Grout Curtain - USACE Rehabilitation Method (1) | $36,000,000 | $134,831,453 | 30.980% | $41,770,784 | $18,000,000 |
| | **TOTAL** | $45,400,000 | $147,301,245 | | $45,633,926 | |

Notes:
1. USACE Methodology to Support Clay Core during Construction not defined. Cost excluded from Estimated Cost
2. CARPI Cost Estimate extended to include application of elastomeric coating system to waterproof Water Quality Control Wells
3. Cost Share based on Major Capital Replacement in USA/DRBC Contract
4. Carpi Quotation to USACE March 2, 2006 for $1,400,943 with Exclusions

# *Appendix A*

# *USACE Cost Estimates*

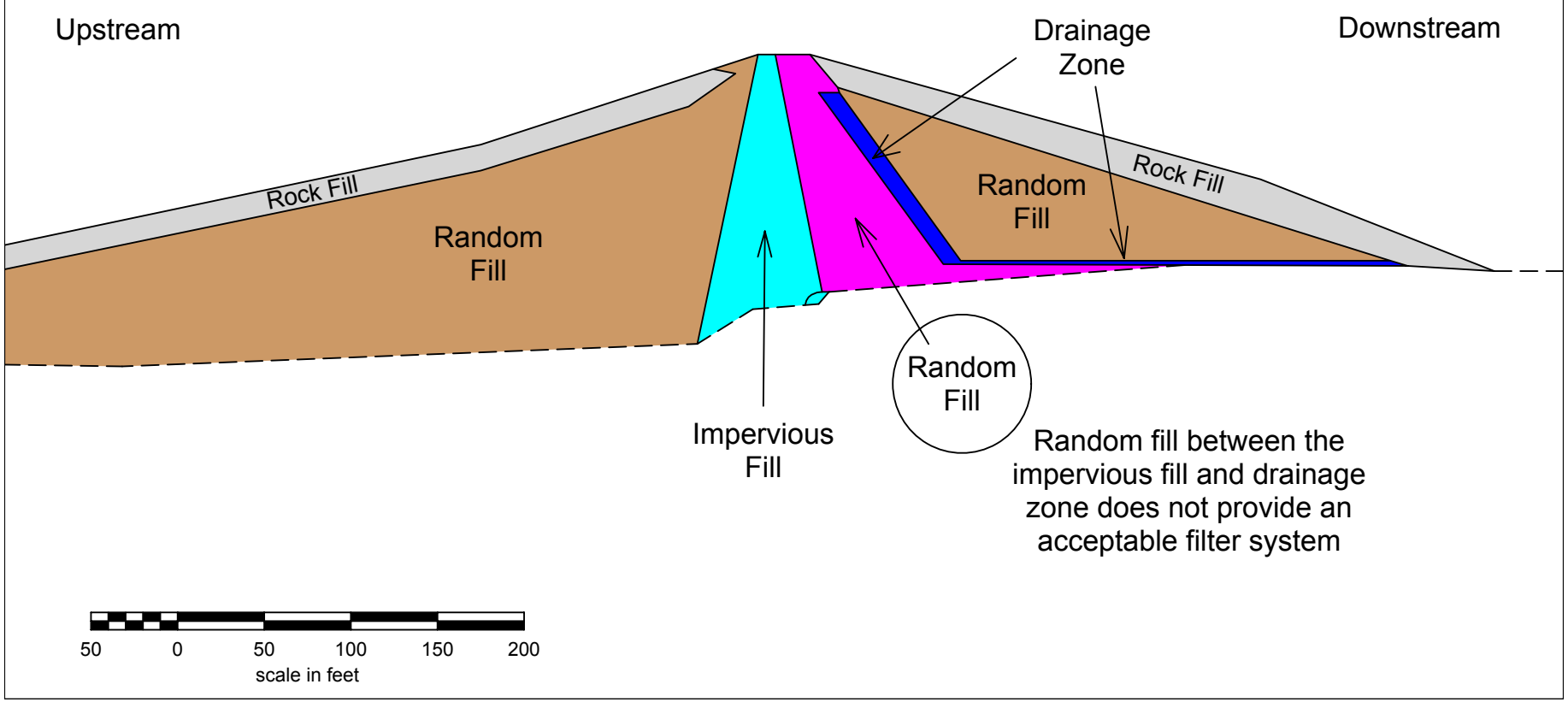
**Comparison of Cost Estimates for Anticipated CENAP Dam Modifications**

| Dam | USACE Dam Safety Investment Plan (26 Jan 2011) | | Rogers (19 Jun 2010) | |
|---|---|---|---|---|
| | Est Rehab Cost (2010 dollars) | Rehab Method | Est Rehab Cost (2010 dollars) | Rehab Method |
| Beltzville | $17.9M | Excavate downstream face and install new filter; extend grout curtain. | $18M | Excavate downstream face and install new filter; extend grout curtain. |
| Blue Marsh & Dike A | $105.3M | Install cut-off wall across entire embankment and Dike A. | $8M | Excavate downstream face and install new filter. [Did not include any work on Dike A.] |
| Bernville | $6.3M | Install 24 relief wells; install flap gates on pressure conduit outlets. | ** | ** |
| Jadwin | $9.3M | Install 50 relief wells. | ** | ** |
| Prompton | $24.4M | Everything we did in Phases I and II, plus raise the filter to the crest. | ** | ** |
| Walter | * | Right abutment grout improvement. | ** | ** |

*Did not estimate; recognized ARRA-funded grout program.

**Did not estimate; was only asked to estimate projects with DRBC cost share.

# Beltzville Dam
## Section Station 9+280



# *Appendix B*

# *CARPI Beltzville Tower Geomembrane Proposal*

March 2, 2006

Bruce Rogers
U.S. Army Corps of Engineers
Wannamaker Building 100 Penn Square East
Philadelphia, PA 19107-3390

Dear Mr. Rogers:

We are pleased to submit this budgetary estimate after discussions for Beltzville Tower. This estimate should be within +20/-20% of final price.

**Pricing assumptions**
The present proposal for Beltzville is based on the following assumptions:

- Installation is done in the dry to elevation 577
- Installation done by divers below elevation 577
- Unlimited access to dam and tower crest during installation
- Weather permits work during construction period
- Euro to USD conversion rate of 1.0 € → 1.20 USD, which affects material costs and some labor costs

TYPE OF SOLUTION
The geomembrane solution will entail installing a geomembrane system to cover and waterproof the entire exterior face of the intake tower at Beltzville dam. Installations that mirror the tower were done on the intake tower of Scais dam (1993) and the air intake Paradella dam (1996). Additionally, we have completed complex shapes on dams at Chambon dam (1991), La Girotte (1994), and Butgenbach (2004) along with underwater installations at Lost Creek (1997) and Platanovrissi (2002).

**Figure 1 - Scais tower (Italy 1993) - The CARPI geomembrane system was installed around the entire tower and has been performing without any maintenance.**

The installation at Beltzville consists of:

1. Submersible watertight perimeter (stainless steel) seal along the foundation
2. Non-submersible watertight perimeter (stainless steel) at top of tower
3. Tensioning profiles (stainless steel) installed vertically to hold geomembrane to tower
4. Geocomposite (PVC geomembrane 2.5 mm with geotextile 500 gram/ square meter) in 2.1 meter widths
5. Geonet drainage layer beneath geocomposite
6. Two drainage conduits at bottom of geomembrane system.

**Figure 2 - Paradela air intake (Portugal 1996) - The tower was completed in less than 10 days during the fall of 1996 and has been working without any maintenance.**

## 1.0 QUANTITIES

### 1.1 Four faces of Beltzville Tower

- Geomembrane System covering the upstream face of sides of tower between elevations 517 and 668.
- Geomembrane System covering the upstream face of front and back of tower between elevations 540 and 668. See attached drawing at end of proposal

**Total 16,500 square feet**

## 1.0 SUPPLY TIME

Time for supply and delivery of material to be installed on site is approximately 3 to 6 months from date of order.

## 1.0 INCLUDED IN THE PROPOSAL BY CARPI

1. Final detailed design of the geosynthetic system
2. Design documentation will consist of at least:
   - 3 drawings and
   - 10 pages of text specification
3. Materials, fabrication, and installation of PVC geocomposite
4. Supply of all the materials needed for the execution of the works as described in the present proposal (geomembrane SIBELON CNT 3750 [liner material], geonet, and all stainless steel profiles and perimeter anchorage, including all connecting devices). Shipments of material will include a certificate from the manufacturer stating lot or roll numbers, date of manufacture and guarantee in that the materials conform the requirement of the specifications.
5. Materials and fabrication of stainless steel batten strips
6. Shipment of materials to staging area
7. Mobilization of crew to site including diving crew
8. All labor needed for the installation of the waterproofing system including diving crew. The labor rates include all salary, social charges, insurance, fringe benefits, holidays, traveling expenses, etc.
9. All tools needed for the installation of the waterproofing system.
10. Supply and operation of suspended platform and scaffolding
11. Cost of sanitary facilities onsite
12. Cost of storage facility onsite
13. Mobilization / Demobilization of material and equipment
14. Supply and operation of hoisting equipment for all activities regarding installation of membrane fastening, an allowance has been made that needs to be verified per site conditions

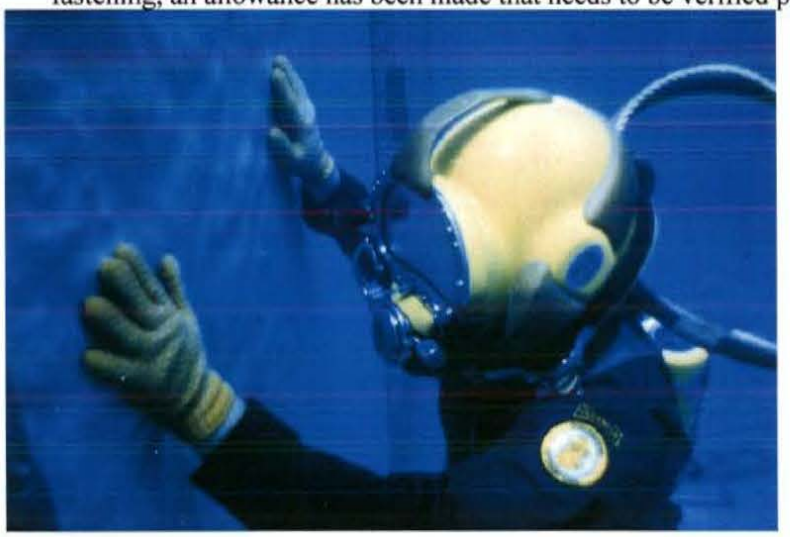


**Figure 3 - US Army Corps of Engineering REMR project (1995) - CARPI and Oceaneering executed a two phase program in the mid-1990s with the Corps to adapt our system for underwater installation. Pictured is the test tank installation by a diver during the project.**

15. Royalties on patents
16. Internal Quality Control on installation
17. Shipping of installation tools to dam
18. Food and lodging of all personnel
19. Cost for office trailer. We have included the costs for typical phone charges from office trailer. (Note – Will phones be available from site?)
20. Testing of geomembrane system after installation
21. One full characterization of geomembrane by an independent test laboratory

22. Supply of electricity at crest level
23. Relevant quality control certificates and internal quality control
24. Custom duties on imported materials
25. Written warranty of 2 years for material and installation.
26. Final report (update of drawings and design specification)
27. Standard Contractor Insurance

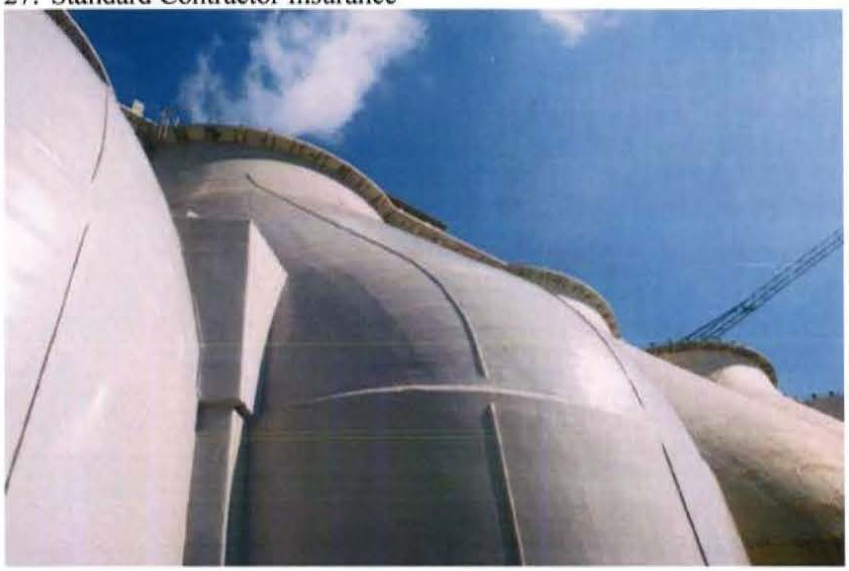


**Figure 4 – La Girotte dam (France 1994) – We had several campaigns to line the arches of this multi-arch dam during the 1990s. The shape is very complicated and the owner of the dam searched for solutions to the leakage and cracking problem for more then 40 years before settling on the CARPI system.**

## 1.0 NOT INCLUDED IN THE PROPOSAL BY CARPI

1. Activities for work if reservoir levels cannot be maintained within agreed upon limits
2. Costs for bonds
3. Insurance above standard insurance requirements for contractors
4. Work does not include site preparation or civil works (i.e. dredging, cofferdams, grading for deployment of equipment, sediment removal, removal of shotcrete, etc.)
5. Work does not include cost of surface preparation
6. Work does not include costs of drilling and installing discharge holes for compartments
7. Work does not include costs of concrete plinth beam with associated geocomposite if required
8. Cost for security at site
9. Contingency for bad weather days
10. Extra work (surface prep in the dry) for CARPI workers will be priced at ~ $80/hour regular time.
11. Cost of any taxes other than customs duty
12. Local sales tax if applicable

## 2. PRICES

TABLE A

| Option | DESCRIPTION | QUANTITY | PRICES IN ~~CANADIAN~~ U.S.$ DOLLARS (Lump Sum) | INSTALLATION TIME (Time on site once material & equipment are in place) |
|---|---|---|---|---|
| I | Geomembrane System covering the four faces of Beltzville Tower | 16,500 square feet of geocomposite system | $1,400,943 +20/- 10% | ~12 to 14 weeks |

Final design details, provided they are not substantial, will not alter the listed price.

Unit Prices will be calculated for a total quantity as specified above +/- 5 %.

The prices for the external waterproofing system on the upstream face of Beltzville Tower are valid for waterproofing works contracted by end of 2006. Note – We have not experienced any significant inflation of prices in last few years and will evaluate as we proceed to fix the above price for a more extended period. The main variance in pricing over the last few years has been the fluctuation in price of the Euro, given that most of our material and some of our workforce are procured in Euros.

Installation based on continuous uninterrupted operations. We intend to work 6 days a week. We will need to discuss how to handle bad weather which is not included. On other projects, we have used standby rates based on a 40 hour week for crew to minimize costs for CARPI and owner.

**Figure 5 - Chambon dam (France - 1991) – CARPI installed its geosynthetic system around the piers of the dam as pictured which solved the AAR problem at this dam. The owner also did saw cuts through the dam after the membrane dried out the dam for several years.**

**Figure 6 – Lost Creek dam (California 1997) - The CARPI system was installed over this 28,000 sq. foot upstream face, doing 25% of the installation underwater. The installation has now been in service for 9 years without any maintenance and has solved the seepage problem at the dam.**

## 2.0 PAYMENTS

### 2.1 Payment schedule

As an example:

20 % within 30 days of order
20 % upon completion of mobilization and material to site
20% after first month of operations
20% after second month of operations
10% upon completion of onsite work
10% two months after end of work

or mutually acceptable unit price schedule.

## 2.0 TRANSFER OF PAYMENTS

All payments by bank transfer to CARPI USA's Bank Account in Virginia.

Interest on delayed payments, interest will be charged (Prime rate + 5 % on annual basis), compounded daily.

## 3. CONCLUDING REMARKS

We look forward to working with U.S. Army Corps of Engineers on the rehabilitation of Beltzville Tower.

Warmest regards.

John A. Wilkes, P.E.
President, CARPI USA

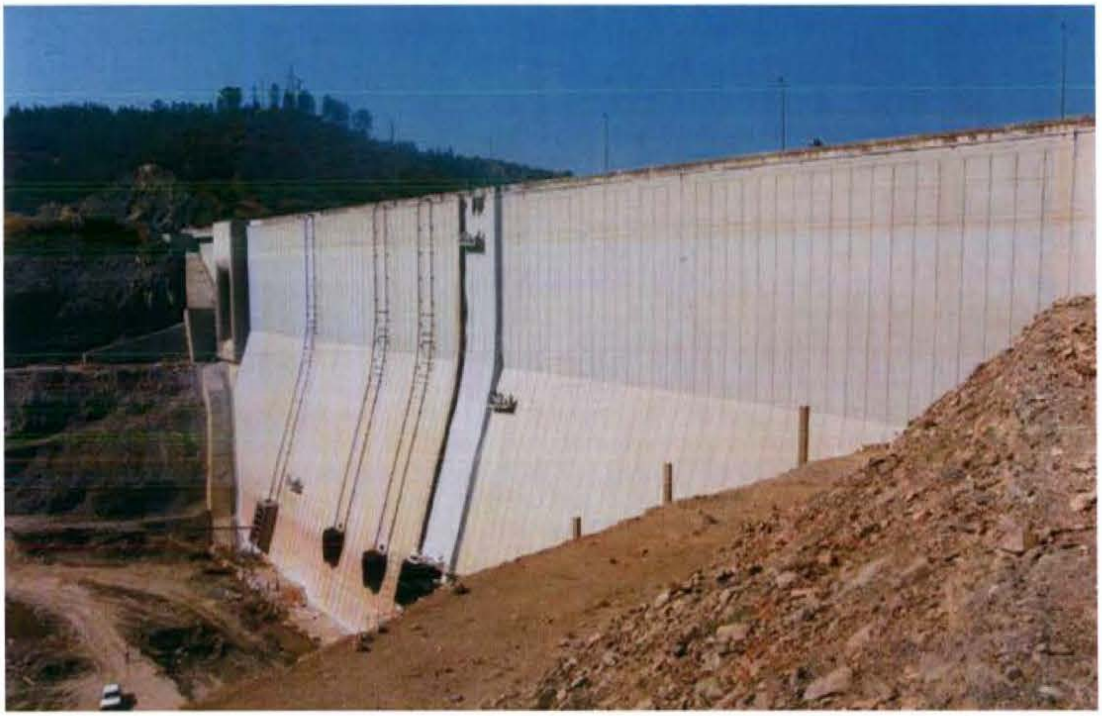
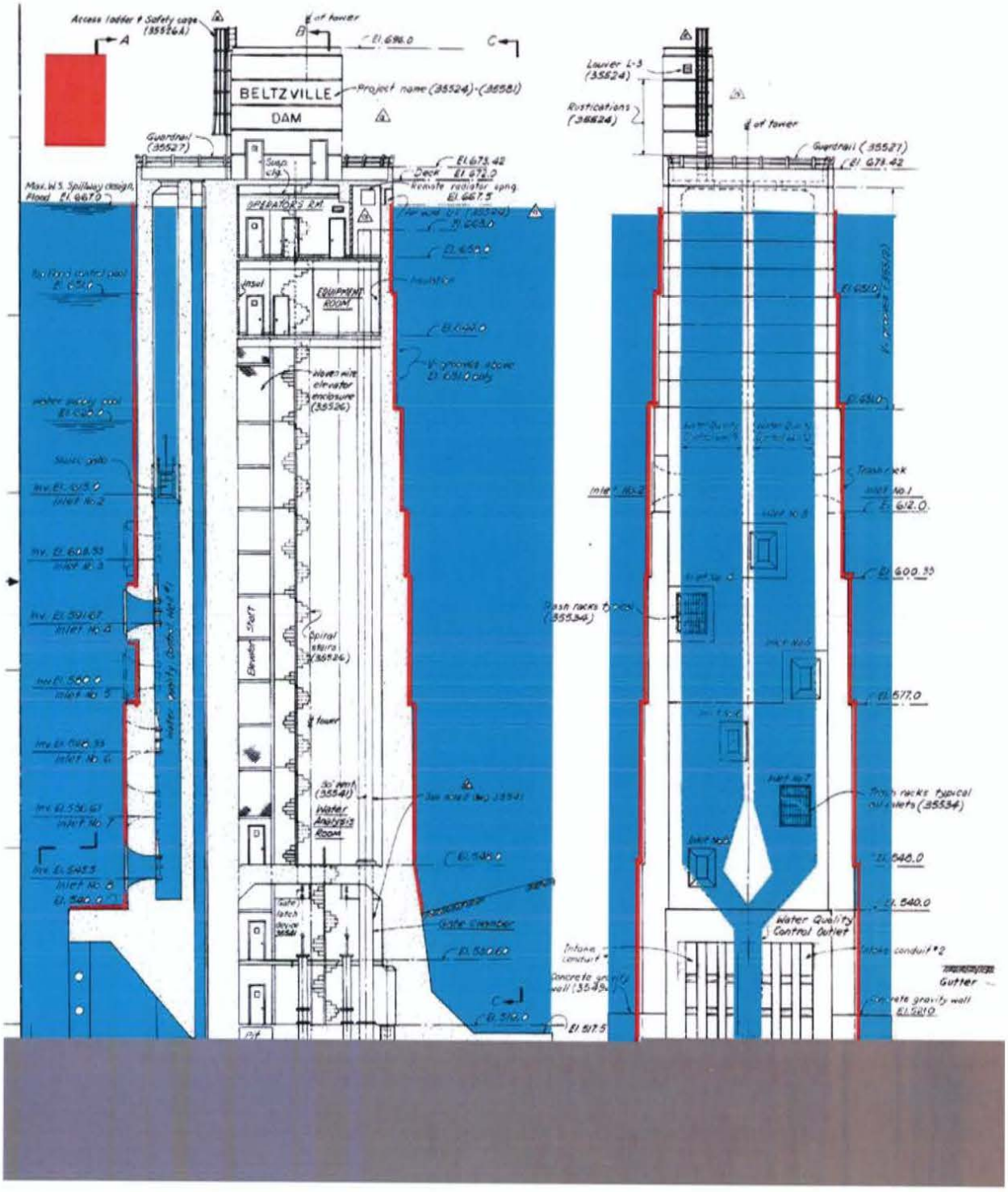


**Figure 7 – Pracana dam (Portugal 1992) – This dam suffered from severe AAR, with cracks in the upstream face that one could stick an entire arm into. The upstream cracks were patched and the CARPI system installed to reduce the water feeding the AAR problem. The dam has now been in service for 15 years without any additional rehabilitation.**




Red indicates area for geomembrane system installation

# *Appendix C*

# *Document Review*

## BELTZVILLE DAM

Documentation List Provided by USACE – Philadelphia District

| *DATE* | *TITLE* | *COMMENTS* |
|---|---|---|
| 1964 | Water Supply and Water Quality Control Study Beltzville Reservoir, Lehigh River Basin, PA | NOT PERTINENT |
| 1964 | Lehigh River Basin, Pohopoco Creek, PA, Beltzville Dam and Reservoir, Design Memo No. 1, Hydrology and Hydraulics | NOT PERTINENT |
| **1964** | **Lehigh River Basin, Pohopoco Creek, PA, Beltzville Dam and Reservoir, Design Memo No. 2, Site Selection** | **REVIEWED** |
| 1964 | Lehigh River Basin, Pohopoco Creek, PA, Beltzville Dam and Reservoir, Design Memo No. 3, Supplement No. 1 to GDM | NOT PERTINENT |
| 1964 | Lehigh River Basin, Pohopoco Creek, PA, Beltzville Dam and Reservoir, Design Memo No. 4, Preliminary Master Plan | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| 1964 | Lehigh River Basin, Pohopoco Creek, PA, Beltzville Dam and Reservoir, Design Memo No. 4A, Draft of the Preliminary Master Plan | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| **1964, 1965** | **Lehigh River Basin, Pohopoco Creek, PA, Beltzville Dam and Reservoir, Design Memo No. 5, Real Estate Design Memorandum** | **REVIEWED** |
| **1965** | **Lehigh River Basin, Pohopoco Creek, PA, Beltzville Dam and Reservoir, Design Memo No. 6, Site Geology (2 Copies)** | **REVIEWED** |
| 1965 | Lehigh River Basin, Pohopoco Creek, PA, Beltzville Dam and Reservoir, Design Memo No. 7, Concrete Aggregates Investigations | NOT PERTINENT |
| 1965 | Lehigh River Basin, Pohopoco Creek, PA, Beltzville Dam and Reservoir, Design Memo No. 8, Highway Relocation | NOT PERTINENT |

| *DATE* | *TITLE* | *COMMENTS* |
|---|---|---|
| **NA 1965?** | **Lehigh River Basin, Pohopoco Creek, PA, Beltzville Dam and Reservoir, Design Memo No. 8, Highway Relocation Testing Embankment Materials** | **REVIEWED** |
| 1967 | Lehigh River Basin, Pohopoco Creek, PA, Beltzville Dam and Reservoir, Design Memo No. 8, Highway Relocation Supplement 1 | NOT PERTINENT |
| 1965 | Lehigh River Basin, Pohopoco Creek, PA, Beltzville Dam and Reservoir, Design Memo No. 9, Utility Relocations | NOT PERTINENT |
| 1965 | Beltzville Dam and Reservoir Township Road Relocation Drainage Computations | NOT PERTINENT |
| 1967 | Lehigh River Basin, Pohopoco Creek, PA, Beltzville Dam and Reservoir, Design Memo No. 9, Utility Relocations Supplement No. 1 | NOT PERTINENT |
| **1966** | **Lehigh River Basin, Pohopoco Creek, PA, Beltzville Dam and Reservoir, Design Memo No. 10, Outlet Works** | **REVIEWED** |
| **1966** | **Lehigh River Basin, Pohopoco Creek, PA, Beltzville Dam and Reservoir, Design Memo No. 11, Embankment and Foundations** | **REVIEWED** |
| 1967 | Lehigh River Basin, Pohopoco Creek, PA, Beltzville Dam and Reservoir, Design Memo No. 11, Embankment and Foundations, Supplement 1 | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| 1966 | Lehigh River Basin, Pohopoco Creek, PA, Beltzville Dam and Reservoir, Design Memo No. 12, Spillway | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| 1966 | Lehigh River Basin, Pohopoco Creek, PA, Beltzville Dam and Reservoir, Design Memo No. 13, Access Roads and Operational Facilities | NOT PERTINENT |
| 1966 | Beltzville Dam and Reservoir of Bridge on Relocated LR 13015 over Pohopoco Creek | NOT PERTINENT |

| *DATE* | *TITLE* | *COMMENTS* |
|---|---|---|
| 1966 | Beltzville Dam and Reservoir Relocated Township Roads 397 and 437 | NOT PERTINENT |
| 1967 | Lehigh River Basin, Pohopoco Creek, PA, Beltzville Dam and Reservoir, Design Memo No. 14, Water Supply Regulation, Instrumentation, and Sedimentation | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| 1967 | Lehigh River Basin, Pohopoco Creek, PA, Beltzville Dam and Reservoir, Volume 1, Specifications for Construction of Embankment, Spillway, Outlet Works, Road, Grounds Utilities | POSSIBLY PERTINENT |
| 1967 | Beltzville Dam and Reservoir Intake Tower Quantities | NOT PERTINENT |
| 1968 | Lehigh River Basin, Pohopoco Creek, PA, Beltzville Dam and Reservoir, Design Memo No. 15, Reservoir Cleaning, Fish and Wildlife Facilities | NOT PERTINENT |
| 1968 | Quantities by Dam Design Section Beltzville Dam | NOT PERTINENT |
| 1969 | Lehigh River Basin, Pohopoco Creek, PA, Beltzville Dam and Reservoir, Design Memo No. 16, Public Use Plan | NOT PERTINENT |
| 1969 | Outlet Works for Beltzille Dam, Pohopoco Creek, PA, Hydraulic Model Investigation | NOT PERTINENT |
| 1969 | Beltzville Reservoir Clearing Zone 1 | NOT PERTINENT |
| 1970 | Lehigh River Basin, Pohopoco Creek, PA, Beltzville Dam and Reservoir, Design Memo No. 17, Instrumentation | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| **1970** | **Lehigh River Basin, Pohopoco Creek, PA, Beltzville Lake, Condition Report No. 1** | **REVIEWED** |

| *DATE* | *TITLE* | *COMMENTS* |
|---|---|---|
| 1970 | Beltzville Reservoir Area, Proposal for a Recreational Fossil Collecting Locality | NOT PERTINENT |
| **1971** | **AS-BUILT DRAWINGS – USACE Philadelphia District – Beltzville Dam and Reservoir, March 1971** | **REVIEWED** |
| 1971 | Lehigh River Basin, Pohopoco Creek, PA, Beltzville Dam and Reservoir, Design Memo No. 18, Master Plan | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| **1967, 1971** | **Lehigh River Basin, Beltzville Lake, Pohopoco Creek, PA, Final Foundation Report (3 Copies)** | **REVIEWED** |
| **1971** | **Lehigh River Basin, Pohopoco Creek, PA, Beltzville Lake, Condition Report No. 2** | **REVIEWED** |
| 1972 | Lehigh River Basin, Pohopoco Creek, PA, Beltzville Lake, Operation and Maintenance Manual | NOT PERTINENT |
| 1972 | Lackawaxen River, Flood Control Project, General Edgar Jadwin Dam and Pompton Lake, Operation and Maintenance Manual | NOT PERTINENT |
| 1972 | Lehigh River Basin, Lehigh River, PA, Francis E. Walter Dam, Operation and Maintenance Manual | NOT PERTINENT |
| **1973** | **Lehigh River Basin, Pohopoco Creek, PA, Beltzville Lake, Condition Reports No. 3 & 4, Dam Outlet Works & Spillway** | **REVIEWED** |
| 1974 | Lehigh River Basin, Pohopoco Creek, PA, Beltzville Dam and Reservoir, Design Memo No. 18A, Appendices to Master Plan, Recreation Resources Management | NOT PERTINENT |
| 1975 | Outlet Works for Beltzille Dam, Pohopoco Creek, PA, Prototype Tests | NOT PERTINENT |

| *DATE* | *TITLE* | *COMMENTS* |
|---|---|---|
| 1975 | Lehigh River Basin, Pohopoco Creek, PA, Beltzville Lake, Condition Report No. 5 | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| 1977 | Recreation Tests Outlet Works for Beltzville Dam, Pohopoco Creek, PA, Final Report | NOT PERTINENT |
| 1977 | Lehigh River Basin, Pohopoco Creek, PA, Beltzville Lake, Condition Report No. 6 | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| 1978 | Beltzville Dam Lake Project, Water Quality Data Report | NOT PERTINENT |
| 1979 | Lehigh River Basin, Pohopoco Creek, PA, Beltzville Lake, Condition Report No. 7 | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| 1980 | Lehigh River Basin, Pohopoco Creek, PA, Beltzville Lake, Report on Final Cost Allocation | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| 1980 | Beltville Dam Investigation Report, Water Quality Gate Damage | NOT PERTINENT |
| 1980 | Beltzville Lake Jadwin Dam Pompton Lake F.E. Walter Dam and Reservoir Maintenance Work Final Work | POSSIBLY PERTINENT |
| 1981 | Beltzville Reservoir Project Evaluation of Planning for Fish and Wildlife | NOT PERTINENT |
| 1981 | Report Intake Tower Improvements at Beltzville Dam FE Walter Dam | NOT PERTINENT |
| 1984 | Beltzville and Blue Marsh Lake Pre/Post Project Study District Working Papers | POSSIBLY PERTINENT |

| DATE | TITLE | COMMENTS |
|---|---|---|
| 1984 | Penn Forest Pumped Storage Study | NOT PERTINENT |
| 1985 | Beltzville Dam-Break Analysis | NOT PERTINENT |
| 1985 | Beltzville Dam Francis E. Walter Pumped Storage Study | NOT PERTINENT |
| 1985 | Beltzville Lake, Pohopoco Creek, PA, Water Control Manual Revised | NOT PERTINENT |
| 1989 | Beltzville Lake, Pohopoco Creek, PA, Dam Safety Plan | NOT PERTINENT |
| 1990 | Beltzville Dam and Lake Annual Dam Inspection Pre-Inspection Brochure | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| 1992 | Underwater Inspection of Five Dams (8 Copies) | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| 1993 | Lehigh River Basin, Pohopoco Creek, PA, Beltzville Lake, Condition Report No. 11 | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| 1993 | Beltzville Dam and Reservoir Lehigh Basin Beltzville Lake Service Bridge Condition Report | NOT PERTINENT |
| 1994 | Beltzville Lake Periodic Dam Inspection, Pre-Inspection Brochure | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| 1994 | Summary Report of Hydrologic and Hydraulic Analyses of Dam Failure of Penn Forest and Wild Creek Dams | NOT PERTINENT |

| *DATE* | *TITLE* | *COMMENTS* |
|---|---|---|
| 1995 | Alkali Aggregate Reactions in Hydro Electric Plants and Dams | NOT PERTINENT |
| 1998 | Lehigh River Basin, Pohopoco Creek, PA, Beltzville Lake, Condition Report, Dam, Outlet, and Water Works, and Spillway, Periodic Inspection Report, No. 12 | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| **2003** | **Lehigh River Basin, Pohopoco Creek, PA, Beltzville Lake, Condition Report, Dam, Outlet, and Water Works, and Spillway, Periodic Inspection Report, No. 13** | **REVIEWED** |
| **2005** | **Report for Beltzville Intake Tower, AAR Monitoring Program: Results for Year 5 Monitoring, Lehigh, PA, Acres International Group, Final Report, February 2005** | |
| **2006** | **CARPI USA Beltzville Tower Proposal Letter to USACE Philadelphia District , March 2, 2006; installation of a geomembrane system to cover and waterproof the entire exterior face of the intake tower at Beltzville dam** | **REVIEWED** |
| **2008** | **Lehigh River Basin, Pohopoco Creek, PA, Beltzville Lake, Condition Report, Dam, Outlet, and Water Works, and Spillway, Periodic Inspection Report, No. 14** | **REVIEWED** |
| NA | Dam Safety Engineering Regulations Binder | **POSSIBLY PERTINENT** |

## BLUE MARSH DAM

Documentation Provided by USACE – Philadelphia District

| DATE | TITLE | REMARKS |
|---|---|---|
| 1959 | Blue Marsh Dam Site and Reservoir, Geology | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| 1960 | Schuylkill River Basin, Tulpehocken Creek, Pa, Blue Marsh Dam and Reservoir, Design Memo No. 1, Site Selection, (2 Copies) | NOT PERTINENT |
| 1964 | Schuylkill River Basin, Tulpehocken Creek, Pa, Blue Marsh Dam and Reservoir, Design Memo No. 2, Hydrology and Hydraulics | NOT PERTINENT |
| 1964, 1965 | Schuylkill River Basin, Tulpehocken Creek, Pa, Blue Marsh Dam and Reservoir, Design Memo No. 3, Geology, (4 Copies) | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| 1959-1961, 1974 | Schuylkill River Basin, Tulpehocken Creek, Pa, Blue Marsh Dam and Reservoir, Design Memo No. 4, General Design Memo Supplement No. 1 | NOT PERTINENT |
| 1966 | Schuylkill River Basin, Tulpehocken Creek, Pa, Blue Marsh Dam and Reservoir, Design Memo No. 5, Land Requirements | NOT PERTINENT |
| 1969 | Schuylkill River Basin, Tulpehocken Creek, Pa, Blue Marsh Dam and Reservoir, Design Memo No. 6, Concrete Aggregates | NOT PERTINENT |
| 1970 | Blue Marsh Dam, Berks County, PA, Landowners' Meeting, Tulpehocken Area HS, Bernville, PA | NOT PERTINENT |
| 1971 | Blue Marsh Dam and Reservoir Project, Berks County, PA, Design Memo No. 7, Real Estate | NOT PERTINENT |
| 1971 | Blue Marsh Dam and Reservoir , Design Memo No. 8, Embankment and Spillway (2 Copies) | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |

| DATE | TITLE | REMARKS |
|---|---|---|
| 1972 | Schuylkill River Basin, Tulpehocken Creek, Pa, Blue Marsh Dam and Reservoir, Ecologic Simulation of Blue Marsh Reservoir, Appendix B (2 Copies) | NOT PERTINENT |
| 1973 | Blue Marsh Dam and Reservoir , Design Memo No. 9, Outlet Works (2 Copies) | NOT PERTINENT |
| 1973 | Blue Marsh , Design Memo No. 10, Access Roads and Operational Facilities | NOT PERTINENT |
| 1973 | Project Proposal for Development of a State Park Along Tulpehocken Creek, “Blue Marsh State Park” | NOT PERTINENT |
| 1973 | Blue Marsh , Design Memo No. 11, Highway Relocations | NOT PERTINENT |
| 1973 | Blue Marsh , Design Memo No. 12, Utility Relocations, Part I | NOT PERTINENT |
| 1973 | Blue Marsh , Design Memo No. 12, Utility Relocations, Part II | NOT PERTINENT |
| **1973** | **Blue Marsh , Design Memo No. 13, Bernville Protective Works** | **REVIEWED- NOT NECESSARY-NOT PART OF DRBC CONTRACT FOR WATER STORAGE** |
| 1973 | Blue Marsh , Design Memo No. 14, Reservoir Clearing | NOT PERTINENT |
| 1973 | Blue Marsh , Design Memo No. 16, Cemetery Relocation | NOT PERTINENT |
| 1973 | Schuylkill River Basin, Tulpehocken Creek, Pa, Blue Marsh Lake, Geological Report on Real Estate Tract, No. 305 (2 Copies) | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |

| DATE | TITLE | REMARKS |
|---|---|---|
| 1973 | Supplemental to the Final Environmental Impact Statement, Blue Marsh Lake Project, Tulpehocken Creek, PA | NOT PERTINENT |
| 1974 | Blue Marsh , Design Memo No. 19, Instrumentation and Sedimentation | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| 1974 | Blue Marsh Lake ,Operation and Maintenance Manual | NOT PERTINENT |
| 1974 | Historical Survey, Blue Marsh Lake Project | NOT PERTINENT |
| 1975 | Schuylkill River Basin, Tulpehocken, PA, Blue Marsh Lake, Preliminary Case Report on Gruber Wagon Works, Pleasant Valle, Penn | NOT PERTINENT |
| 1977 | Final Report, Investigation of the Arsenic Conditions at the Blue Marsh Lake Project Site, Pennsylvania | NOT PERTINENT |
| **1978** | **AS-BUILT DRAWINGS – USACE Philadelphia District – Blue Marsh Lake, September 20, 1978** | **REVIEWED** |
| 1978 | Schuylkill River Basin, Tulpehocken Creek, PA, Blue Marsh Lake, Condition Report, Dam Outlet Works, Spillway, and Bernville Protective Works, Periodic Inspection, No. 1 | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| 1978 | Historic Structure Report, Gruber Wagon Works, BML | NOT PERTINENT |
| 1978 | Blue Marsh, Lake Vacuum System | NOT PERTINENT |
| 1978 | Blue Marsh Lake, Excavation, Embankment, Engineering, Considerations and Instructions for Field Personnel | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |

| DATE | TITLE | REMARKS |
|---|---|---|
| 1978 | Board of Investigation Report, Fatal Accident Involving Subcontractors Employee at Blue Marsh Lake Projection on October 6, 1978 | NOT PERTINENT |
| 1976, REV. 1980 | Blue Marsh Lake, Schuylkill River Basin Tulpehocken Creek, Berks County, PA and Bernville Protective Area, Condition Report, 11-84 | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| 1980 | Blue Marsh Lake, Berks County, PA Small Hydropower Addition, Reconnaissance Report (Preliminary) | NOT PERTINENT |
| 1980 | Final Report Sanitary Sewer Evaluation Analysis and Recommendations, Blue Marsh Lake, Berks County, PA | NOT PERTINENT |
| 1981 | Schuylkill River Basin, Tulpehocken Creek, PA, Blue Marsh Lake, Condition Report, Dam Outlet Works, Spillway, and Bernville Protective Works, Periodic Inspection, No. 2 | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| 1981 | Operation and Maintenance Manual, Blue Marsh Lake, Schuylkill River Basin, Tulpehocken Creek, Berks County, PA | NOT PERTINENT |
| 1981 | Schuylkill River Basin, Tulpehocken Creek, PA, Blue Marsh Lake, Condition Report, Dam Outlet Works, Spillway, and Bernville Protective Works, Periodic Inspection, No. 3 | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| 1982 | Blue Marsh Dam, Hydroelectric Feasibility Study | NOT PERTINENT |
| 1982 | Schuylkill River Basin, Tulpehocken Creek, PA, Blue Marsh Lake, Condition Report, Dam Outlet Works, Spillway, and Bernville Protective Works, Periodic Inspection, No. 4 | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| 1983 | Schuylkill River Basin, Tulpehocken Creek, PA, Blue Marsh Lake, Condition Report, Dam Outlet Works, Spillway, and Bernville Protective Works, Periodic Inspection, No. 5 | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| 1983 | Proposal to the Electric Power Research Inst for Field Evaluation of Small Hydroplant using Modular Components of Blue Marsh Dam, Berks County, PA | NOT PERTINENT |

| DATE | TITLE | REMARKS |
|---|---|---|
| 1985 | Schuylkill River Basin, Tulpehocken Creek, PA, Blue Marsh Lake, Condition Report, Dam Outlet Works, Spillway, and Bernville Protective Works, Periodic Inspection, No. 6 | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| **1986** | **Embankment Criteria and Performance Report, Blue Marsh Lake, PA Schuylkill River Basin, Tulpehocken Creek, Berks County, Pennsylvania** | **REVIEWED** |
| **1987** | **Final Foundation Report, Blue Marsh Lake, PA, Schuylkill River Basin, Tulpehocken Creek, Berks County, PA** | **REVIEWED** |
| 1987 | Schuylkill River Basin, Tulpehocken Creek, PA, Blue Marsh Lake, Condition Report, Dam Outlet Works, Spillway, and Bernville Protective Works, Periodic Inspection, No. 7 | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| 1989 | Blue Marsh Lake, Tulpehocken Creek, PA, Dam Safety Plan | NOT PERTINENT |
| 1989 | Schuylkill River Basin, Tulpehocken Creek, PA, Blue Marsh Lake, Condition Report, Dam Outlet Works, Spillway, and Bernville Protective Works, Periodic Inspection, No. 8 | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| 1992 | Blue Marsh Lake, Tulpehocken Creek, Berks County, PA, Condition Report, Periodic Inspection Report No. 9 (3 Copies) | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| 1992 | Underwater Inspection of Five Dams (8 Copies) | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| 1994 | Blue Marsh Lake, Tulpehocken Creek, Berks County, PA, Condition Report, Periodic Inspection Report No. 10 | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| 1999 | Schuylkill River Basin, Tulpehocken Creek, PA, Blue Marsh Lake, Condition Report, Dam Outlet Works, Spillway, and Bernville Protective Works, Periodic Inspection, No. 11 | NOT NECESSARY - SUPPLEMENTAL INFO PROVIDED |
| **2004** | **Schuylkill River Basin, Tulpehocken Creek, PA, Blue Marsh Lake, Condition Report, Dam Outlet Works, Spillway, and Bernville Protective Works, Periodic Inspection, No. 12** | **REVIEWED** |

| DATE | TITLE | REMARKS |
|---|---|---|
| **2009** | **Schuylkill River Basin, Tulpehocken Creek, PA, Blue Marsh Lake, Condition Report, Dam Outlet Works, Spillway, and Bernville Protective Works, Periodic Inspection, No. 13** | **REVIEWED** |
| NA | Blue Marsh Binder | POSSIBLY PERTINENT |
| NA | Dam Safety Engineering Regulations Binder | POSSIBLY PERTINENT |
| NA | Before the FERC Application for License for a Minor Hydroelectric Power Project, 5 Megawatts or Less, Blue Marsh Hydroelectric Project | NOT PERTINENT |

## DRBC

**Dams Documentation Provided by DRBC**

| *DATE* | *TITLE* | *COMMENTS* |
|---|---|---|
| 1966 | Contract between the United States of America and the Delaware River Basin Commission for Water Storage Space in Beltzville Reservoir, October 31, 1966 | REVIEWED |
| 1971 | Contract between the United States of America and the Delaware River Basin Commission for Water Storage Space in Blue Marsh Reservoir, May 14, 1971 | REVIEWED |
| 1996 | Beltzville Intake Tower – Alkali – Aggregate Reaction Impacts on Structural Performance and Operation; Prepared by Acres International Corporation | REVIEWED |
| 2010 | USACE Philadelphia District Operations Division Letter to DRBC, April 1, 2010; Notification that both Beltzville and Blue Marsh Dams have been classified as DSAC III – Moderate to High Risk | REVIEWED |
| 2010 | DRBC Letter to USACE Philadelphia District, April 13, 2010; Requesting additional information to enable DRBC to prepare for its financial obligations and water storage needs in connection with the remediation of Beltzville and Blue Marsh Dams | REVIEWED |
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## O'BRIEN & GERE ENGINEERS

**Dams Documentation obtained by O'Brien & Gere from internet sources**

| *DATE* | *TITLE* | *COMMENTS* |
|---|---|---|
| **1985** | **The REMR Bulletin, Vol 2, No. 3, September 1985, *Performance of Repairs to Stop Leakage in Intake Structures – Beltzville Dam;* Repair history of surface treatments** | **REVIEWED** |
| **2008** | **USACE / DRBC Report, Enhancing Multi-jurisdictional Use and Management of Water Resources for the Delaware River Basin, NY, NJ, PA, and DE** | **REVIEWED** |
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# *Appendix D*

# *Major Replacement Cost Estimates*

**Beltzville Dam**
**Toe Drain Installation**
**Preliminary Budget 05.02.13**

| # | Bid Item | Quantity | Unit | Unit Price | Total | Notes |
|---|---|---|---|---|---|---|
| **A** | ***SITE PREPARATION*** | | | | | **200,000.00** |
| **B** | ***EARTHWORK*** | | | | | **1,800,000.00** |
| **C** | ***DRAINAGE SYSTEM*** | | | | | **300,000.00** |
| **D** | ***SITE RESTORATION*** | | | | | **100,000.00** |
| | Subtotal | | | | | 2,400,000.00 |
| | Contingency | | | 35% | | 800,000.00 |
| | **Contractor Costs** | | | | | **3,200,000.00** |
| | Engineering + Design Costs | | | 10% | | 320,000.00 |
| | CM + Inspection Costs | | | 10% | | 320,000.00 |
| | **Project Costs** | | | | | **3,840,000.00** |

**Beltzville Dam**
**Tower Membrane**
**Preliminary Budget 05.02.13**

| # | Bid Item | Quantity | Unit | Unit Price | Total | Notes |
|---|---|---|---|---|---|---|
| **A** | ***SITE PREPARATION*** | | | | | **250,000.00** |
| **B** | ***DREDGING*** | | | | | **600,000.00** |
| **C** | ***EXTERIOR MEMBRANE*** | | | | | **2,200,000.00** |
| **D** | ***INTERIOR MEMBRANE*** | | | | | **250,000.00** |
| **E** | ***SITE RESTORATION*** | | | | | **100,000.00** |
| | Subtotal | | | | | 3,400,000.00 |
| | Contingency | | | 35% | | 1,200,000.00 |
| | **Contractor Costs** | | | | | **4,600,000.00** |
| | Engineering + Design Costs | | | 10% | | 450,000.00 |
| | CM + Inspection Costs | | | 10% | | 450,000.00 |
| | **Project Costs** | | | | | **5,500,000.00** |

**Beltzville Dam**
**Filter Relocation**
**Preliminary Budget 05.02.13**

| # | Bid Item | Quantity | Unit | Unit Price | Total | Notes |
|---|---|---|---|---|---|---|
| **A** | ***SITE PREPARATION*** | | | | | **875,000.00** |
| **B** | ***EARTHWORK*** | | | | | **15,175,000.00** |
| **C** | ***SITE RESTORATION*** | | | | | **650,000.00** |
| **D** | ***GROUTING*** | | | | | **5,500,000.00** |
| | Subtotal | | | | | 22,200,000.00 |
| | Contingency | | | 35% | | 7,800,000.00 |
| | **Contractor Costs** | | | | | **30,000,000.00** |
| | Engineering + Design Costs | | | 10% | | 3,000,000.00 |
| | CM + Inspection Costs | | | 10% | | 3,000,000.00 |
| | **Project Costs** | | | | | **36,000,000.00** |

**Blue Marsh Dam**
**Toe Drain Installation**
**Preliminary Budget 05.02.13**

| # | Bid Item | Quantity | Unit | Unit Price | Total | Notes |
|---|---|---|---|---|---|---|
| **A** | ***SITE PREPARATION*** | | | | | **100,000.00** |
| **B** | ***EARTHWORK*** | | | | | **560,000.00** |
| **C** | ***DRAINAGE SYSTEM*** | | | | | **90,000.00** |
| **D** | ***SITE RESTORATION*** | | | | | **40,000.00** |
| | Subtotal | | | | | 790,000.00 |
| | Contingency | | | 35% | | 280,000.00 |
| | **Contractor Costs** | | | | | **1,070,000.00** |
| | Engineering + Design Costs | | | 10% | | 105,000.00 |
| | CM + Inspection Costs | | | 10% | | 105,000.00 |
| | **Project Costs** | | | | | **1,280,000.00** |

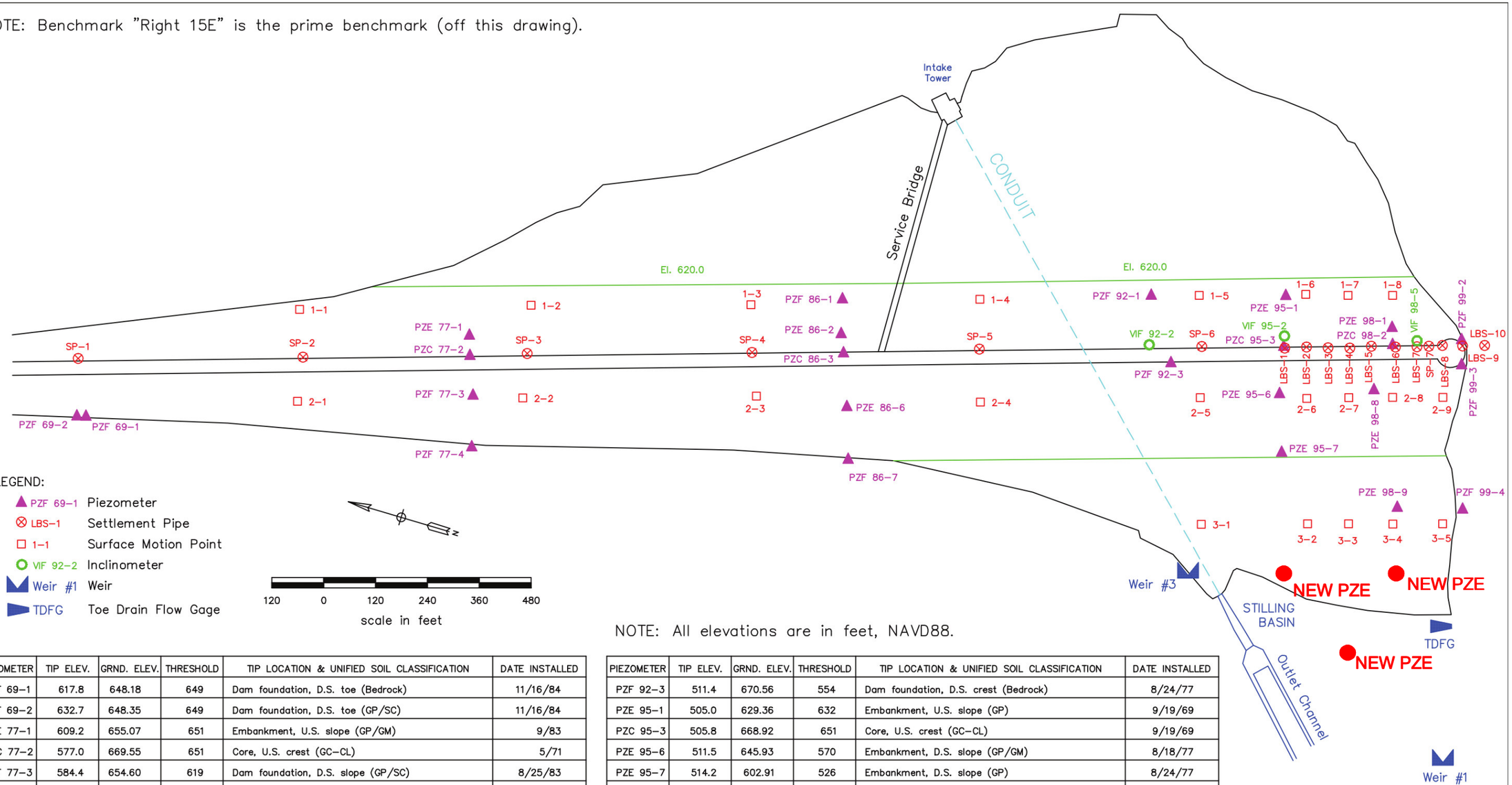
**Blue Marsh Dam**
**Filter Relocation**
**Preliminary Budget 05.02.13**

| # | Bid Item | Quantity | Unit | Unit Price | Total | Notes |
|---|---|---|---|---|---|---|
| **A** | ***SITE PREPARATION*** | | | | | **210,000.00** |
| **B** | ***EARTHWORK*** | | | | | **5,025,000.00** |
| **C** | ***SITE RESTORATION*** | | | | | **125,000.00** |
| | Subtotal | | | | | 5,360,000.00 |
| | Contingency | | | 35% | | 1,880,000.00 |
| | **Contractor Costs** | | | | | **7,240,000.00** |
| | Engineering + Design Costs | | | 10% | | 725,000.00 |
| | CM + Inspection Costs | | | 10% | | 725,000.00 |
| | **Project Costs** | | | | | **8,690,000.00** |

# *Appendix E*

# *Piezometer Data*

NOTE: Benchmark "Right 15E" is the prime benchmark (off this drawing).




NOTE: All elevations are in feet, NAVD88.

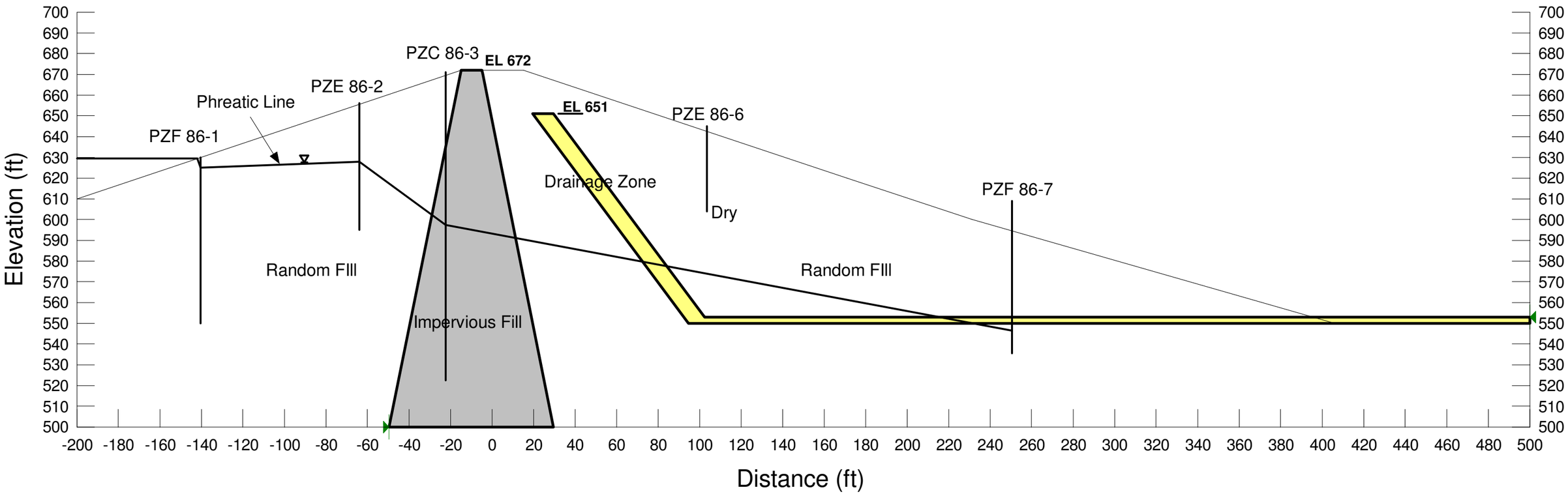
| PIEZOMETER | TIP ELEV. | GRND. ELEV. | THRESHOLD | TIP LOCATION & UNIFIED SOIL CLASSIFICATION | DATE INSTALLED |
|---|---|---|---|---|---|
| PZF 69-1 | 617.8 | 648.18 | 649 | Dam foundation, D.S. toe (Bedrock) | 11/16/84 |
| PZF 69-2 | 632.7 | 648.35 | 649 | Dam foundation, D.S. toe (GP/SC) | 11/16/84 |
| PZE 77-1 | 609.2 | 655.07 | 651 | Embankment, U.S. slope (GP/GM) | 9/83 |
| PZC 77-2 | 577.0 | 669.55 | 651 | Core, U.S. crest (GC-CL) | 5/71 |
| PZF 77-3 | 584.4 | 654.60 | 619 | Dam foundation, D.S. slope (GP/SC) | 8/25/83 |
| PZF 77-4 | 569.4 | 618.49 | 619 | Dam foundation, D.S. toe (Bedrock) | 9/7/83 |
| PZF 86-1 | 550.1 | 629.90 | 631 | Dam foundation, U.S. slope (GP w/some cobbles) | 4/71 |
| PZE 86-2 | 595.2 | 655.31 | 651 | Embankment, U.S. slope (GP) | 6/71 |
| PZC 86-3 | 522.7 | 669.40 | 651 | Core, U.S. crest (GC-CL) | -- |
| PZE 86-6 | 604.2 | 642.71 | 609 | Embankment, D.S. slope (GP/GM) | 8/9/77 |
| PZF 86-7 | 535.4 | 604.21 | 606 | Dam foundation, D.S. toe (SP/SM) | 8/5/77 |
| PZF 92-1 | 512.2 | 629.86 | 631 | Dam foundation, U.S. slope (GP) | -- |

| PIEZOMETER | TIP ELEV. | GRND. ELEV. | THRESHOLD | TIP LOCATION & UNIFIED SOIL CLASSIFICATION | DATE INSTALLED |
|---|---|---|---|---|---|
| PZF 92-3 | 511.4 | 670.56 | 554 | Dam foundation, D.S. crest (Bedrock) | 8/24/77 |
| PZE 95-1 | 505.0 | 629.36 | 632 | Embankment, U.S. slope (GP) | 9/19/69 |
| PZC 95-3 | 505.8 | 668.92 | 651 | Core, U.S. crest (GC-CL) | 9/19/69 |
| PZE 95-6 | 511.5 | 645.93 | 570 | Embankment, D.S. slope (GP/GM) | 8/18/77 |
| PZE 95-7 | 514.2 | 602.91 | 526 | Embankment, D.S. slope (GP) | 8/24/77 |
| PZE 98-1 | 564.2 | 654.34 | 651 | Embankment, U.S. slope (GP) | 2/24/70 |
| PZC 98-2 | 555.8 | 668.71 | 651 | Core, U.S. crest (GC-CL) | 2/26/70 |
| PZE 98-8 | 509.3 | 648.78 | 600 | Dam foundation, D.S. slope (GP/GM) | 9/1/77 |
| PZE 98-9 | 487.9 | 567.13 | 505 | Embankment, D.S. slope (GP/GM) | 8/29/77 |
| PZF 99-2 | 591.3 | 670.55 | 651 | Left Abutment, U.S. crest (Bedrock) | 8/5/83 |
| PZF 99-3 | 570.7 | 670.92 | 651 | Left Abutment, D.S. crest (Bedrock) | 8/19/83 |
| PZF 99-4 | 509.2 | 565.46 | 566 | Left abutment, D.S. side (Bedrock) | 8/31/83 |

LEHIGH RIVER BASIN
BELTZVILLE LAKE
POHOPOCO CREEK, PENNSYLVANIA

GEOTECHNICAL
INSTRUMENTATION PLAN

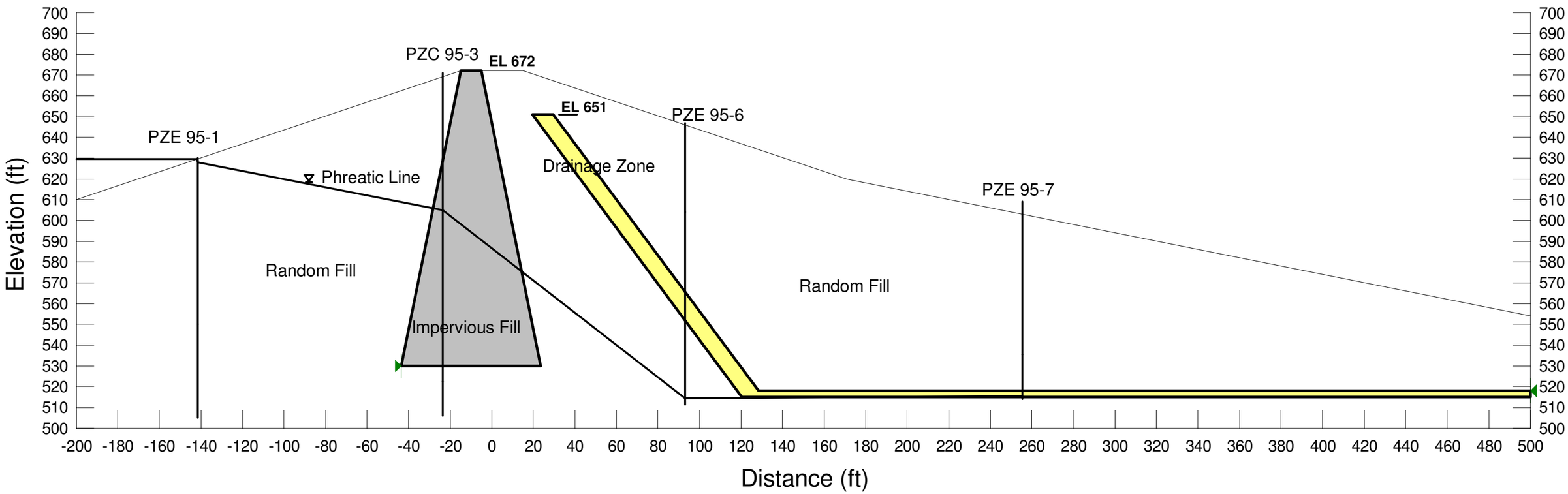
20 Dec 08




O'BRIEN & GERE

BELTZVILLE DAM - Sta. 9+280
PIEZOMETER DATA FROM 1/08

| | | |
|---|---|---|
| MFN | 50046 | March 2013 |




O'BRIEN & GERE

BELTZVILLE DAM - Sta. 9+610
PIEZOMETER DATA FROM 1/08

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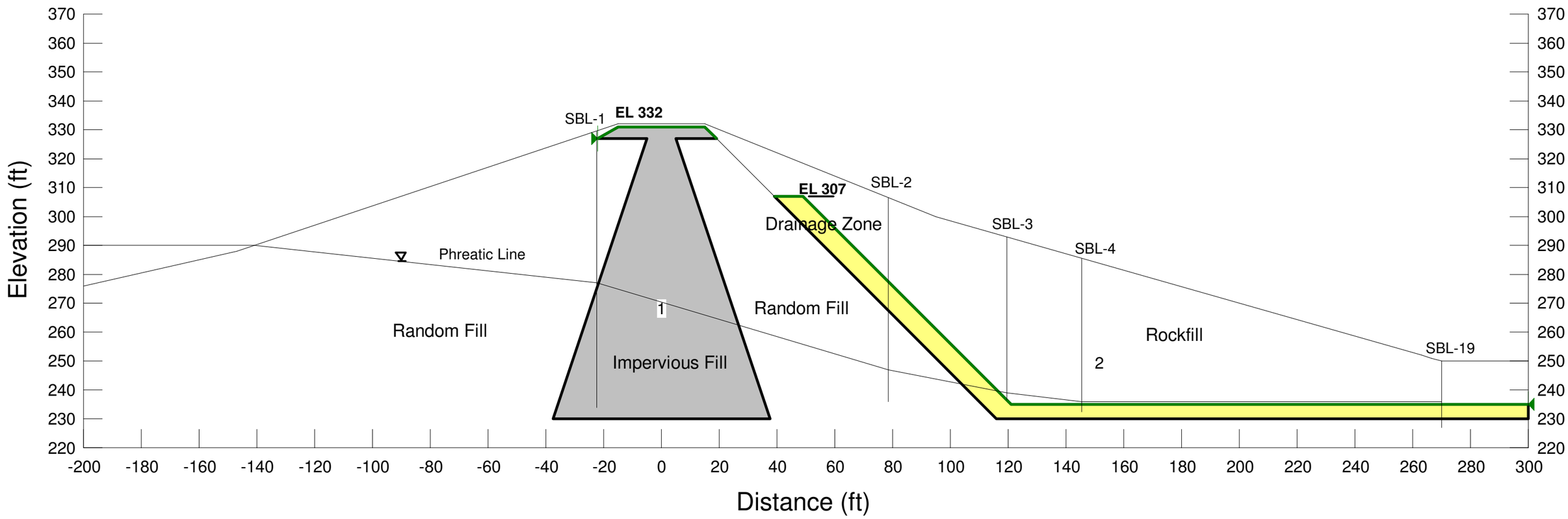
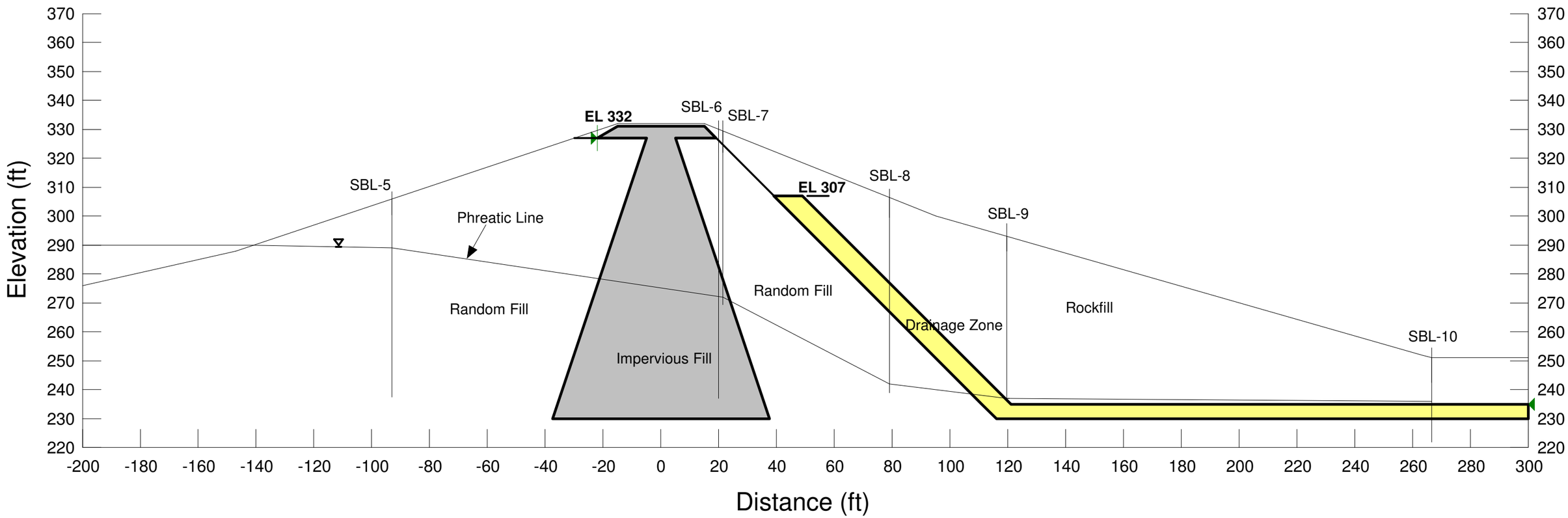
|---|---|---|
| MFN | 50046 | March 2013 |




O'BRIEN & GERE

BLUE MARSH DAM - Sta. 15+55
PIEZOMETER DATA FROM 7/1/08

| | | |
|---|---|---|
| MFN | 50046 | March 2013 |




O'BRIEN & GERE

BLUE MARSH DAM - Sta. 18+00
PIEZOMETER DATA FROM 7/1/08

| | | |
|---|---|---|
| MFN | 50046 | March 2013 |