CHATFIELD STORAGE REALLOCATION PROJECT

TECHNICAL ADVISORY COMMITTEE (TAC)
TAC RECOMMENDATION DOCUMENT - No. 04

SUBJECT: Gravel Pond – Pervious Dike Rev 02

Date: May 26, 2016

Purpose:

This document serves as the basis of the TAC recommendation on the subject noted above.

Background:

The FR/EIS discusses the Gravel Pond in Chatfield State Park in Appendix 3 – Gravel Pond Protection of Appendix M – Recreation Facilities Modification Plan. Appendix 3 consists of a study by Boyle/AECOM to assess layout options, costs and the practicality of protecting the Gravel Pond. The Gravel Pond is used for activities not otherwise generally practiced in Chatfield Reservoir, such as scuba diving, paddle boarding, life saving classes, canoeing and fishing.

The Gravel Pond is reported to have higher water quality than the Chatfield Reservoir. This is believed to be due to the Gravel Pond being fed primarily from groundwater. The Gravel Pond maintains an elevation generally between El 5439 and El 5441, higher than the present normal level of Chatfield of El 5432.

The Boyle/AECOM conceptual memo of November 2008 was discussed at a project participants meeting on December 5, 2008, following which Boyle/AECOM made recommendations.

The Boyle/AECOM memo recommended that a dike be constructed on the north of the pond to El 5457 and a dike on the east to El 5446.5 to prevent the Gravel Pond being inundated at the proposed normal water level of El 5444.0. The memo also recommended that the north dike and foundation be significantly pervious to allow the water surface in the Gravel Pond to rise and lower with the water surface in Chatfield Reservoir. Boyle/AECOM noted that "the seepage and stability should be further evaluated and analyzed at preliminary design" (Sec 4.1).

During the Preliminary Design the concept of a pervious dike was revisited by the RM2 design consultant, HDR. The Gravel Pond was also discussed briefly at the first TAC meeting on April 27, 2016 where its unique use was confirmed by CPW. HDR raised questions about the practicality of constructing and maintaining such a pervious dike, and the benefits that would result. Based on the discussion at the TAC and a review of HDR's concerns, the consensus of HDR and the PgM Team was that the primary intent of protecting the water quality was adequately met by the north dike and east dike and there was no additional benefit provided by a pervious embankment. The

current water levels in the Gravel Pond meet the recreational requirements of the users and there has been no desire expressed to raise the water surface to El 5444.0, or to have it fall below El 5439 by draining into the Chatfield Reservoir.

Referenced Documents:

FR/EIS, July 2013 Map 2.7 and Map 3.5 of Appendix M
FR/EIS, July 2013. Appendix 3 – Gravel Pond Protection to Appendix M
HDR, May 13, 2016. Memo Gravel Pond Pervious Dike Preliminary Design

Requested Action:

The TAC is requested to review the referenced documents and consider the recommendation from the design consultant and the PgM Team that the pervious dike concept be dropped since the proposed dikes are sufficient to provide the desired protection of the water quality in the Gravel Pond.

Request Rationale:

The preliminary designer has raised issues with construction of a pervious dike that would also serve as the road base for the main perimeter road in the Park. Also, the benefit of a pervious dike is questionable if the current water quality and water levels meet the requirements of Park users.

TAC Recommendation:

The TAC recommends that the pervious dike concept be dropped since the proposed dikes are sufficient to provide the desired protection of the water quality in the Gravel Pond

TAC Voting:

The TAC members in attendance voted on this Recommendation, in accordance with the TAC Charter Section C. The vote tally was 12 votes to "agree"; 2 votes to "accept"; and 0 votes to "reject" the Recommendation. The recommendation is based on the total votes for "agree" and "accept". TAC adopted voting procedures also require that any Member voting to "reject" a recommendation to propose alternative(s) for consideration to move the issue forward.

TAC Rationale:

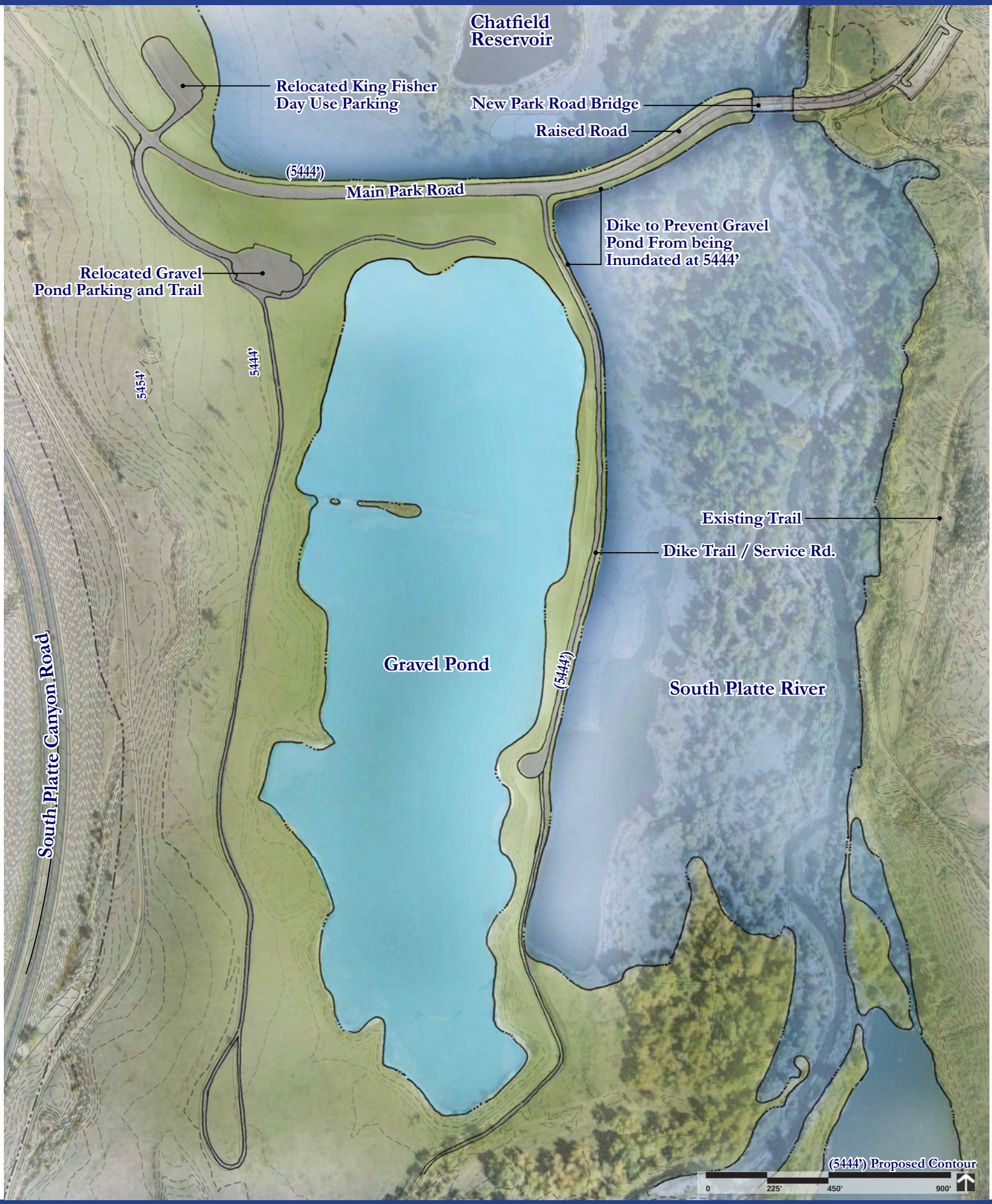
The preliminary designer has raised issues with construction of a pervious dike that would also serve as the road base for the main perimeter road in the Park. Also, the benefit of a pervious dike is questionable if the current water quality and water levels are maintained and meet the requirements of Park users.

On behalf of the TAC:

Kevin Urie
Chair

Jennifer Anderson
Vice Chair

Map 2.7. Kingfisher/Gravel Ponds/ Platte River Areas Existing Conditions



Map 3.5. King Fisher/Gravel Ponds/Platte River Trailhead Modification Plan (5444' Elevation)

Appendix 3. Gravel Pond Protection

Boyle Engineering
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TECHNICAL MEMORANDUM

Date:	December 18, 2008
To:	Tom Keith, EDAW|AECOM Scott Sinn, EDAW|AECOM
From:	Blaine Dwyer and Wendy Daughtry, Boyle|AECOM
Subject:	Chatfield Reservoir Storage Reallocation – Mitigation Support

1.0 INTRODUCTION AND BACKGROUND

As part of the on-going mitigation planning for the Chatfield Reservoir Storage Reallocation Project (Project), Boyle|AECOM has been retained by EDAW|AECOM to assess layout options, potential costs, and the practicality of protecting the large Gravel Pond at the south end of Chatfield Reservoir.

The Project proposes a new reservoir operating elevation of 5,444 ft. At this elevation, the Gravel Pond will be inundated as will a segment of the park road north of the Gravel Pond and other facilities in the surrounding area (including a parking area on the east side of the Gravel Pond). Currently, the Gravel Pond reportedly has greater water clarity than the overall reservoir and some of the Pond's existing recreational uses, primarily scuba diving and triathlon training, are expected to be negatively affected by the inundation and anticipated diminished water clarity. (EDAW, 2006) To preserve the Pond's existing water quality and recreational uses, the feasibility of an earthen dike around the Gravel Pond is being considered.

A Concept Memorandum prepared by Boyle dated November 25, 2008, presented conceptual alternatives for the dike including geotechnical designs and preliminary earthwork quantities. The memorandum further discussed dike geometry and layout, site geologic conditions, and potential borrow sources. Upon review of the Concept Memorandum and based on discussions held at a December 5, 2008 meeting with project participants, Boyle was asked to look at two new conceptual dike alternatives.

This memorandum is a follow up to the November 25, 2008 Concept Memorandum and provides preliminary feasibility assessments, including ranges of probable costs, for the two new dike alternatives.

2.0 DIKE ALTERNATIVES

2.1. Alternative 1

For Alternative 1, the park road is routed around the south end of Chatfield Reservoir, beyond the Gravel Pond, resulting in the need for a small dike along the north and east perimeter of the Gravel Pond. For reference, a plan of the proposed Alternative 1 conceptual dike design is attached.

2.1.1. Crest Height

The proposed new normal water level (NWL) for Chatfield Reservoir is 5,444 ft. Based on our understanding and per meeting discussions with project participants on December 5, 2008, the purpose of the proposed dike around the Gravel Pond is to isolate the Pond from the main reservoir pool at the new NWL so that the Gravel Pond's existing water quality and recreational uses can be preserved under normal reservoir operations. The dike is expected to be overtopped whenever the main reservoir pool rises above 5,444 ft. When overtopping does occur, no immediate threat to facility improvements or the public is anticipated since the Gravel Pond area is ultimately within the Chatfield Reservoir area of inundation. Therefore, based on the intended function of the dike, a base crest height of 5,444 ft was selected.

Per USACE guidance as described in Section 3.0, a freeboard of 6 feet for the north dike and 2.5 feet for the east dike was added to the dike crest height to account for estimated wave run-up, wind setup, and embankment settling. The resulting crest elevations of 5,450 ft and 5,446.5 ft were used for the north and east dikes, respectively.

The vertical transition of the crest heights, from 5,450 ft to 5,446.5 ft, was made at a 5% slope.

2.1.2. Dike Layout and Crest Width

The north dike ties into elevation 5,450 ft at the northwest corner of the Gravel Pond. The north dike extends east along the north shoreline of the Gravel Pond then rounds the northeast corner of the Pond and transitions into the east dike which is at elevation 5,446.5 ft. The east dike is generally aligned with the eastern shoreline of the Gravel Pond until it ties back into the existing topography.

EDAW provided USACE hydrologic study data for simulated Chatfield Project operations at the 5,444 ft NWL that showed historical maximum reservoir levels over a 58 year period (1942-2000). Under that scenario, the reservoir level exceeded elevation 5,446.5 ft only six times during the 58 years. Based on this information, the 5,446.5 ft east dike crest elevation appears to be set at a reasonable height for maintaining the general intent of the Gravel Pond dike.

Based on meeting discussions from December 5, 2008, the Alternative 1 dike crest width was set at 12 ft to allow for emergency and/or maintenance vehicle access. The east dike will not serve as a public park roadway.

2.2. Alternative 2

For Alternative 2, the existing park road alignment and S. Platte River crossing north of the Gravel Pond is maintained thus requiring a raised north dike of appropriate crest width to accommodate the given roadway section. In addition, to fully isolate the Gravel Pond area,

a smaller dike that ties into the north dike would be required along the east side of the Gravel Pond. For reference, a plan of the proposed Alternative 2 conceptual dike design is attached.

2.2.1. North Dike Crest Height

As previously stated for Alternative 1, the general intent of the Gravel Pond dike is to retain the main reservoir's proposed NWL (5,444 ft). In addition to this function, for Alternative 2 the top of the north dike must also serve as the park road and South Platte River crossing. Per meeting discussions on December 5, 2008 with project participants, it was determined that the Alternative 2 dike road and bridge crossing should be preliminarily designed to, at a minimum, maintain the current conditions of the existing park road and bridge crossing (i.e., replace in-kind). Under current conditions, the Chatfield NWL is 5,432 ft and the existing bridge deck elevation is 5,445 ft which is an elevation difference of 13 ft. Placing the proposed north dike road/bridge crossing 13 ft above the new Chatfield Reservoir NWL (5,444 ft) results in a north dike crest elevation of 5,457 ft.

Per USACE guidance as described in Section 3.0, a freeboard of 6 feet was estimated for the north dike to account for wave run-up, wind setup, and embankment settling. Since the north dike crest elevation is set 13 feet above the base crest height (5,444 ft), the 6 feet of freeboard is incorporated in the 13 feet.

2.2.2. North Dike Layout and Crest Width

The north dike follows the current park road alignment north of the Gravel Pond and includes the embankment fill for the raised roadway approach and bridge abutments on both sides of the existing South Platte River crossing. Since the top of the north dike will also serve as the park road, the north dike crest width was set at 46 ft based on the required park roadway section provided by EDAW. The roadway section includes two 12 ft travel lanes, two 6 ft bike lanes, two 1 ft shoulders, and an 8 ft wide concrete trail.

A short spur dike is proposed at the far west end of the north dike alignment to tie the dike crest elevation back into the existing topography. Continuing the north dike along the existing park road alignment would require raising the road profile to the dike elevation for a significant distance before catching an existing contour crossing the road at that same elevation. For this conceptual design, the spur dike was selected as the preferred alternative, as opposed to raising the road profile, to minimize the amount of fill material.

2.2.3. East Dike Crest Height

The east dike will not serve as a public park roadway, therefore, elevation 5,444 ft was selected as the base crest height. Per USACE guidance as described in Section 3.0, a freeboard of 2.5 feet was added to the east dike crest height to account for estimated wave run-up, wind setup, and embankment settling. The resulting crest elevation of 5,446.5 ft was used for the east dike conceptual design. This crest elevation appears to be reasonable based on provided USACE hydrologic data discussed under Alternative 1.

The vertical transition of the crest heights, from 5,457 ft to 5,446.5 ft, was made at a 5% slope.

2.2.4. East Dike Layout and Crest Width

The east dike connects to the north dike at the location of the existing parking lot access road and extends south along the east side of the Gravel Pond. The east dike is generally aligned with the eastern shoreline of the Gravel Pond until it ties back into the existing topography. Based on meeting discussions from December 5, 2008, the east dike crest width was set at 12 ft to allow for emergency and/or maintenance vehicle access.

2.3. Dike Overflow

The proposed Gravel Pond dike will be subject to fairly frequent overtopping due to the low crest elevation on the east dike (only 2.5 feet above the reservoir NWL for both Alternatives 1 and 2), making the dike more susceptible to failure. To help protect the dike embankment from washouts, an armored overflow section is proposed on the east dike. The overflow section is intended to protect the dike embankment by allowing the flow to pass into the Gravel Pond area at a specified location that is sufficiently armored to protect against erosion. Subsequently, allowing the water surface on the Gravel Pond side of the dike to rise with the main reservoir pool can help stabilize the dike embankment during overtopping and fluctuating water surface elevations. Dike overtopping will ultimately occur when the main reservoir pool rises more than 2.5 feet above the NWL.

Based on USACE guidance on dam breach characteristics, a 25 ft wide, riprap-armored overflow section was assumed for this conceptual design. (USACE, 1997) The proposed overflow section is presumed to be set slightly above the NWL (i.e., 6-inches; 5,444.5 ft) so that reservoir overflows do not occur during minor fluctuations of the NWL. Overall, the Gravel Pond dike should be designed to withstand fairly frequent overtopping; therefore, the embankment structure and dike stability should be further analyzed and evaluated during preliminary design.

2.4. Side Slopes

Based on prior experience and USACE guidance, the dike outer slopes, both upstream and downstream, are assumed as 3H:1V for conceptual design layout. The influences of geotechnical considerations on the side-slopes are further discussed in Section 4.0.

3.0 FREEBOARD DESIGN

A freeboard height was estimated for both the north and east dikes based on USACE procedures for wave run-up, wind setup, and embankment settling. (USACE, 1976) The north dike is subject to a longer fetch across the proposed raised reservoir pool and thus results in a greater freeboard requirement than the east dike. The resulting required freeboard for the north dike is estimated to be 6 feet. The east dike will experience substantially less wave run-up and wind setup than the north dike given the minor fetch length of the adjacent raised reservoir pool. The resulting required freeboard for the east dike is estimated to be 2.5 feet.

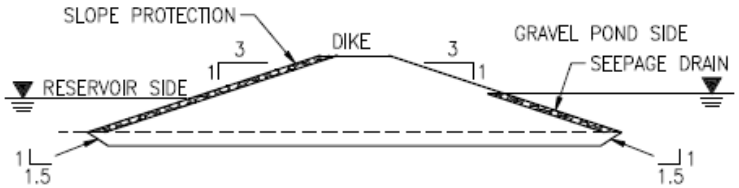
4.0 GEOTECHNICAL DESIGN

The Concept Memorandum presented two alternative geotechnical designs: 1) pervious dike and foundation; and 2) impervious dike and foundation with seepage control. After review of the proposed geotechnical designs, project participants chose to proceed with the pervious dike and foundation alternative; therefore, all discussions in this memorandum regarding the new conceptual dike alternatives assume the pervious design.

4.1. Pervious Dike and Foundation

The pervious concept would allow potentially significant seepage/leakage from the raised reservoir pool to penetrate the dike and its foundation resulting in higher pool level in the Gravel Pond (and conversely lower Gravel Pond pool levels during periods of sufficiently lowered reservoir pool). Under this concept the proposed dike would be constructed of predominantly granular fill available from a local to nearby source. The dike would be designed as an essentially homogeneous section (i.e., constructed of all the same type of material) with a downstream filter zone to allow for safe discharge of seepage to the Gravel Pond (i.e., discharge without the potential for internal erosion or piping of the fill). The filter zone would be constructed of processed aggregate filter compatible with the homogeneous granular fill. The outer slopes of the embankment are assumed as 3H:1V both upstream and downstream. Such slopes should be adequately stable given the anticipated and assumed embankment materials, foundation conditions, and loadings (static, seepage, and seismic) based on prior experience and standard USACE design guidance. (USACE, 2004) Seepage and stability should be further evaluated and analyzed at preliminary design.

Foundation preparation would consist of stripping shallow soils that are loose and/or contain organic matter (preliminary assumed as 1-2 feet maximum depth). Cutoff of the alluvial aquifer would not be included in this alternative concept. It is assumed for the purposes of this study that internal erosion or piping of the finer fraction of the shallow alluvial foundation into the Gravel Pond under seepage gradients from the raised reservoir pool to the Gravel Pond pool (or in the opposite direction during low reservoir pool conditions) would not occur. It will be important to verify or revise this assumption based on site-specific investigations and analyses if this alternative is to be further considered.



PERVIOUS CONCEPT
SCALE: NTS

4.2. Foundation Rockfill

The Concept Memorandum showed the placement of foundation rockfill along the pond banks in locations where the dike embankment would encroach the Gravel Pond and smaller pond to the east. For both dike alternatives discussed in this memorandum, the proposed dike on the east side of the Gravel Pond no longer encroaches the ponds due to the reduced base width; therefore, foundation rockfill is not longer included.

4.3. Slope Protection

Slope protection on the reservoir-side of the dike slopes would be provided, as appropriate, due to the potential for wave erosion. The method of slope protection ultimately selected would depend on the degree of protection required and availability of materials. Methods that would be considered include conventional rock riprap, soil cement, manufactured products (i.e., gravel-filled geoweb, articulated concrete block), and/or reinforced vegetation. Greater protection would be required on the north dike that would be exposed to a significant fetch across the reservoir. Slope protection requirements on the east dike would be less (e.g., potentially smaller riprap size) given the minor fetch length of the adjacent raised reservoir pool in this area.

Erosion protection for side-slopes on the Gravel Pond side may not be required depending on the gradation of the granular embankment fill. If needed, placement of topsoil and grass seeding could be considered with or without synthetic reinforcement (depending on specific site conditions).

4.4. Park Road and Bridge

The raised park road embankment, the extension of the north dike east of the east dike (Alternative 2), would utilize the pervious design concept described above but without the downstream filter/drain zone. Given that water levels on both sides of this embankment would always be the same there is no apparent potential for sustained seepage through the embankment or foundation and accompanying internal erosion or piping. Other than stripping of loose and/or organic surficial soils, no foundation treatment is anticipated. Slope protection would be as described previously for the dike concepts.

5.0 GEOLOGIC CONDITIONS

Preliminary interpretations of geologic conditions along the proposed dike, park road, bridge abutments, and adjacent ground are based on subsurface exploration by others (USACE, 1974) and site reconnaissance conducted by Boyle|AECOM staff on November 11, 2008. These interpretations are the basis for the geotechnical aspects of the conceptual alternatives described in this memorandum. Site subsurface exploration and geotechnical testing will be required to confirm, modify and/or extend these interpretations and to gather additional geologic/geotechnical information to support further evaluation and ultimately design of a selected alternative.

The dike and park road/bridge alignments are underlain by thin surficial soils with some organic content. The depth of these soils appears to be on the order of inches rather than feet based on available exposures in the eroded banks of the gravel ponds at the site. Where vegetation is present, soils tend to be slightly deeper; grass roots are expected to be shallow (on the order of the depth of the soil layer) while willow and cottonwood roots may extend deeper into the alluvial deposits. The surficial soils have developed on underlying alluvial deposits of the South Platte River floodplain. Depths of alluvium at the two boring locations in the vicinity of the existing park road bridge crossing of the S. Platte River are 9 and 36 feet (USACE, 1974). Based on these borings and the alluvial valley setting of the project site, it is estimated that the depth of alluvium may vary between as little as 10-15 feet to as much as 35-40 feet or more beneath the dike and park road embankment alignments. The alluvial deposits are likely predominantly silty to gravelly sand and sandy gravel, with local lenses of sandy clay to clayey sand/gravel. The alluvium is underlain by siltstone and sandstone of the Dawson Formation at the boring locations and it is anticipated that this bedrock unit also underlies the dike and park road raise alignments. These bedrock units are reported to be soft to moderately hard, unweathered to moderately weathered, and slightly to locally highly fractured. The sandstones are calcareous and moderately cemented.

Although not known with certainty pending site-specific subsurface investigations, it is judged likely that the alluvial deposits underlying the site area are an unconfined groundwater aquifer. If the water surface in the existing ponds at the site are assumed coincident with the local groundwater table, then the elevation of the groundwater table beneath the proposed Gravel Pond dike alignment (as inferred from the adjacent pond water levels) is on the order of 4-5 feet higher than the South Platte River to the east. Assuming the unconfined groundwater table discharges to the river, a groundwater gradient on the order of 0.005 toward the river is estimated. Based on this inferred gradient, the boring log descriptions cited previously, and the presence of a number of abandoned shallow alluvial wells in the site area, it is judged that the alluvial deposits underlying the site are moderately to locally highly permeable. Under this preliminary groundwater concept for the site area, it is inferred that the primary source of water in the Gravel Pond and other water filled gravel pits in the vicinity is recharge to the shallow alluvial aquifer from the South Platte River upgradient (i.e., upstream) of the Gravel Pond.

6.0 BORROW SOURCES

A preliminary assessment has been made of potential borrow sources to provide the earth materials necessary for the dike concepts described previously. Potential sources include but are not limited to:

6.1. Chatfield State Park

Alluvial and colluvial deposits are present on the slopes of the existing reservoir. Potential advantages associated with this source include: short haul distance; no royalty cost (assuming mineral rights are currently held by State Parks); ongoing environmental evaluation and permitting process; minimal reclamation requirements if borrow site is below proposed raised pool elevation; abundant granular material; and gain of reservoir storage capacity if borrowing is within limits of raised reservoir pool. Known and potential disadvantages include: uncertainty as to availability of low permeability (i.e., high fines, plastic) soils; and potential dewatering requirements (depending on elevation of borrow area relative to South Platte River and/or reservoir pool).

6.2. Commercial Aggregate Pits

Pit run and processed alluvial sands and gravels are available from commercial sources in the general vicinity of the site. These sources may also provide fine-fraction reject (likely non-plastic) and oversize cobbles/boulders. Potential advantages of these sources include: the ability to specify required gradations (or select from standard gradations); no project-required permitting or reclamation; and the resulting relatively short-notice availability of the materials. Potential disadvantages include: oversize materials predominantly rounded and limited in size; and royalty (i.e., purchase) and haul costs. The closest commercial aggregate supplier to the site is within approximately 4 road miles; other suppliers are located considerably further away and haul costs would increase significantly if one of these sources was used.

7.0 PRELIMINARY EARTHWORK QUANTITIES

Preliminary order of magnitude estimates of earthwork quantities for the pervious geotechnical design (refer to Section 4.0) have been made for the two conceptual dike alternatives identified and evaluated in this memorandum. These quantities are summarized as follows:

Alternative 1	Earthwork Quantities (CY)	Alternative 2	Earthwork Quantities (CY)
		North Dike	
Stripping Excavation	15,000	Stripping Excavation	36,000
Fill Material		Fill Material	
Seepage Drain	5,000	Seepage Drain	6,000
Embankment Fill [A]	51,000	Embankment Fill [A]	235,000
Slope Protection [B]	4,000	Slope Protection [B]	7,000
Overflow (Riprap)	200		
		East Dike	
		Stripping Excavation	10,000
		Fill Material	
		Seepage Drain	3,000
		Embankment Fill [A]	33,000
		Slope Protection [B]	2,000
		Overflow (Riprap)	200
Total Fill Material	**60,200**	**Total Fill Material**	**286,200**

Note that these estimates are based on the assumptions regarding site geologic conditions, preliminary dike/foundation layouts, and the pervious geotechnical design concept discussed previously. These estimates should be expected to change based on site specific investigations and more refined design as part of further evaluation of a selected concept.

[A] Embankment fill quantities include material quantities for backfilling stripping excavation.
[B] Slope protection is assumed to be riprap and bedding.

8.0 CONCEPTUAL OPINIONS OF PROBABLE COSTS

Conceptual opinions of probable costs have been prepared for the two alternative dike concepts evaluated in this memorandum. These cost estimates were developed based on the conceptual level designs detailed above and on our knowledge and experience with similar types of projects in the region. Due to the currently unspecified source of dike embankment fill material, opinions of probable costs have been prepared considering both onsite and offsite borrow (import) sources.

For onsite borrow source cost estimates, the total construction costs reflect a short haul distance, material placement and compaction, and assume that the material would be in suitable condition for direct placement requiring no additional drying or extra processing (i.e., over and above the effort required for typical compactive fill). At this time, locations of potential onsite borrow have not been identified; therefore, it is unknown if onsite borrow material is available or suitable for use in the dike embankment fill. For provided onsite borrow source opinions of probable costs, it was assumed that onsite borrow material is available and acceptable for use in constructing the dike embankment.

For offsite borrow source (import) cost estimates, the total construction costs reflect material purchase price, haul distance, material placement and compaction, and assume that the material would be in suitable condition for direct placement requiring no additional drying or extra processing. For both dike alternatives, it was assumed that riprap/bedding for the shoreline protection and east dike overflow section and the drain/filter material would be obtained from offsite borrow sources due to the specific gradation requirements of the materials.

The opinions of probable costs are provided below:

Conceptual Dike Alternative	Opinion of Cost (Onsite Borrow)	Opinion of Cost (Offsite Borrow)
Alternative 1	$1.0 Million	$3.0 Million
Alternative 2 (North and East Dike)	$2.8 Million	$10.5 Million
Alternative 2 (North Dike Only)	$2.3 Million	$9.0 Million
Alternative 2 (East Dike Only)	$0.5 Million	$1.5 Million

The estimated construction costs for the two conceptual dike alternatives incorporates anticipated variations in the import material unit pricing due to the amount of import material required for the different alternatives. For example, it is expected that the unit price per cubic yard of import embankment fill for Alternative 1 will be more than the embankment fill unit price for Alternative 2 since less import fill material is needed for Alternative 1 than Alternative 2 (i.e., economies of scale).

The estimated construction costs include an allowance for “unlisted items” equal to 20% of the listed items. This allowance provides an estimate for a variety of items that would eventually be included in a detailed cost estimate.

The estimated construction costs also include an allowance for construction contingencies equal to 20% of the base construction cost. Construction contingencies are included to account for undefined or unanticipated conditions as well as project construction cost increases that could result from a variety of factors including:

- Project components and requirements not yet itemized or identified
- Unforeseen conditions or unexpected project development issues
- Special USACE design/construction requirements (i.e., roadway/bridge design, reinforced embankments, flood protection measures)
- Approximations in estimating
- Other unforeseen or unexpected costs

An allowance for the construction contractor's costs for mobilization and demobilization is also included as 7% of the of base construction cost.

The estimated construction costs for Alternative 2 are provided in three different scenarios: 1) the estimated cost for the north and east dike combined; 2) the north dike only; and 3) the east dike only. For each of these scenarios, the provided opinions of costs include only those direct construction costs associated with the identified scenario. Allowances for unlisted items, construction contingencies, and contractor mobilization/demobilization are also included.

Note that these opinions of costs are limited to the assumptions and availability of information previously discussed and only assume those costs associated with direct construction. These opinions of costs do not include roadway surfacing nor allowances for field exploration, design, recreation or environmental mitigation, restoration of onsite borrow sources, permitting, legal/administrative, construction management, or quality assurance. Project participants are recommended to include allowances for these costs in their overall planning level estimates.

9.0 PRELIMINARY CONCLUSIONS

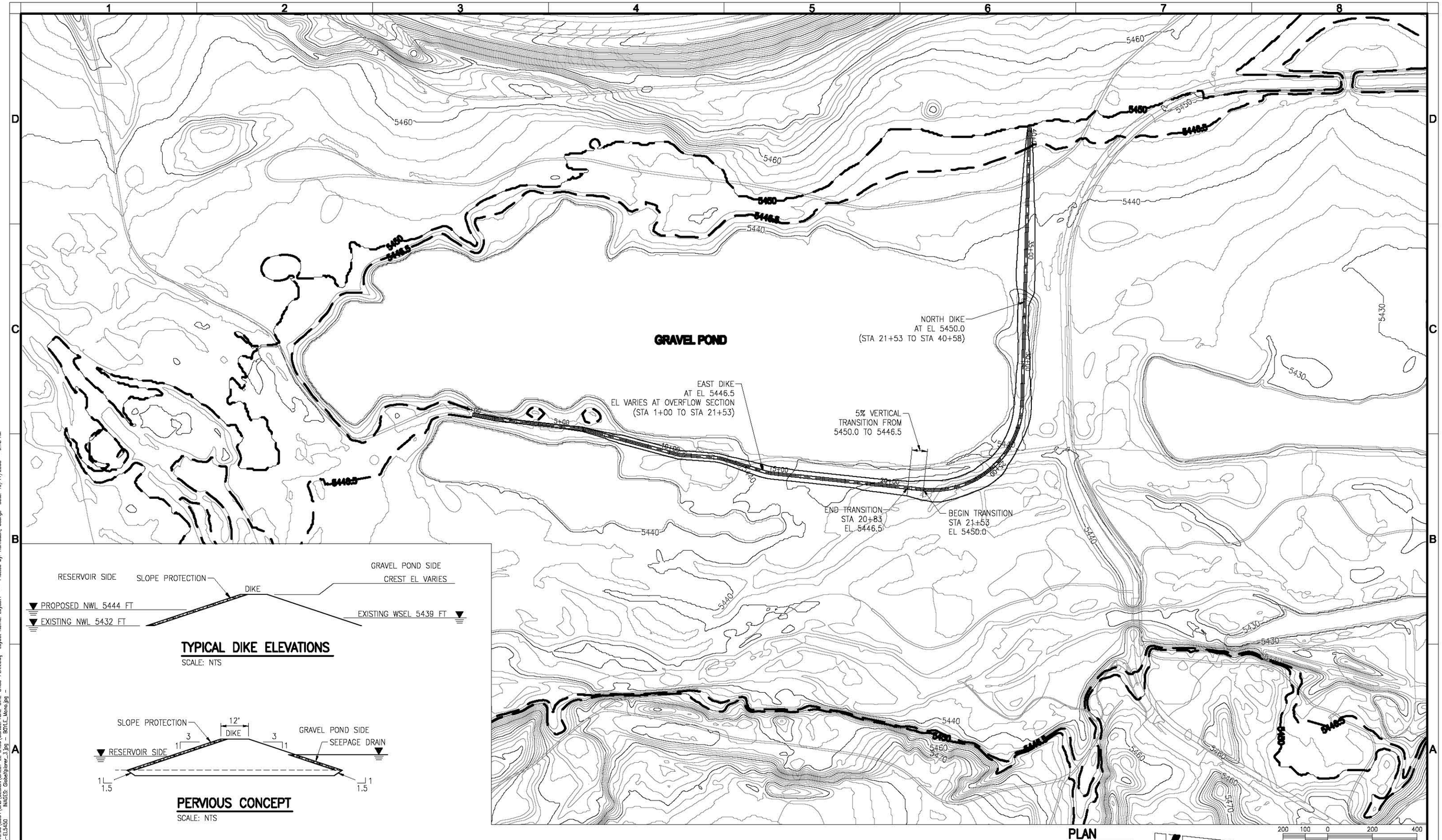
Preliminary conclusions from the conceptual evaluations performed to date and described herein are summarized as follows:

- Construction of a dike to prevent direct inundation of the Gravel Pond by raising the Chatfield Reservoir normal water level appears technically feasible based on the conceptual level evaluations performed to date.
- Maintaining the existing park road alignment and South Platte River crossing location appears technically feasible.
- A pervious dike and absence of foundation cutoff would result in some response in Gravel Pond water level to changes in reservoir water level; estimating the degree and timing of response would require site specific investigations and analyses beyond the scope of this initial assessment.

10.0 REVIEW OF DOCUMENTS AND GUIDELINES

The following documents were reviewed as part of the evaluation covered under this concept memorandum:

1. Boyle|AECOM. *Chatfield Reservoir Storage Reallocation – Mitigation Support* (Concept Memorandum), November 25, 2008.
2. EDAW. Chatfield Reservoir cad files, topography, and surface features, 2008.
3. EDAW. Chatfield Reservoir hydrologic data, December 2008.
4. EDAW. *Chatfield Reservoir Recreation Study, Initial Mitigation Plan*, December 2006.
5. U.S. Army Corps of Engineers (USACE). *EM 1110-2-1420, Hydrologic Engineering Requirements for Reservoirs*, October 31, 1997.
6. U.S. Army Corps of Engineers (USACE). *EM 1110-2-2300, General Design and Construction Considerations for Earth and Rock-Fill Dams*, July 30, 2004.
7. U.S. Army Corps of Engineers (USACE). *ETL 1110-2-221, Wave Runup and Wind Setup on Reservoir Embankments*, November 29, 1976.
8. U.S. Army Corps of Engineers (USACE). *South Platte River Chatfield Lake, Colorado; Roads and Utilities – Stage III*, April 1974.



PLAN
SCALE: 1'=200'

200 100 0 200 400
SCALE IN FEET

TYPICAL DIKE ELEVATIONS
SCALE: NTS

PERVIOUS CONCEPT
SCALE: NTS

REV	DATE	DESCRIPTION	APPR
7			
6			
5			
4			
3			
2			
1			

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
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DESIGNED BY: WD
DRAWN BY: GJH
CHECKED BY: BD
DATE:
PROJECT ENGINEER
REG NUMBER EXP DATE
PROJECT NUMBER 17445.00
CADD STANDARDS BOYLE

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BOYLE ENGINEERING CORPORATION
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LAKEWOOD, COLORADO 80228
(303) 987-3443
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CHATFIELD RESERVOIR MITIGATION

ALTERNATIVE 1
NORTH DIKE CREST ELEVATION 5450.0
EAST DIKE CREST ELEVATION 5446.5

DRAWING
SHEET 1 OF 1 SHEETS

GRAVEL POND

NORTH DIKE AT EL 5457.0
(STA 1+00 TO STA 35+20

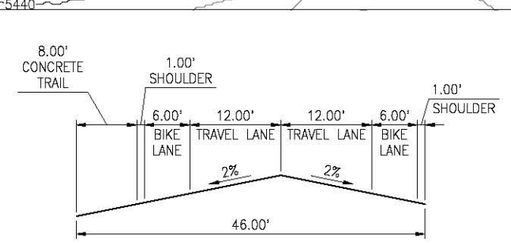
EAST DIKE AT EL 5446.5
EL VARIES AT OVERFLOW SECTION
(STA 1+00 TO STA 28+50)

BEGIN TRANSITION
STA 29+77.2
EL 5457.0

END TRANSITION
STA 27+67.2
EL 5446.5

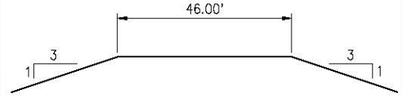
5% VERTICAL
TRANSITION FROM
5457.0 TO 5446.5

BRIDGE



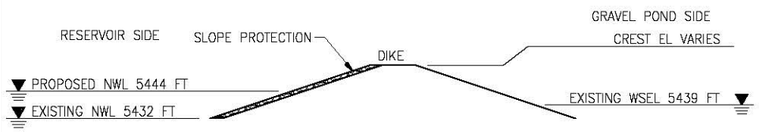
PROPOSED PARK ROAD/BRIDGE CROSS SECTION

SCALE: NTS



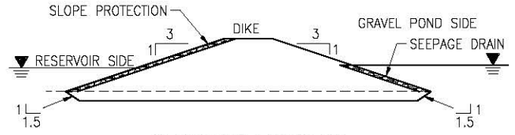
NORTH DIKE

SCALE: NTS



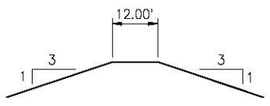
TYPICAL DIKE ELEVATIONS

SCALE: NTS



PERVIOUS CONCEPT

SCALE: NTS



EAST DIKE

SCALE: NTS

PLAN

SCALE: 1'=200'

200 100 0 200 400
SCALE IN FEET

REV	DATE	DESCRIPTION	APPR
7			
6			
5			
4			
3			
2			
1			

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CHATFIELD RESERVOIR MITIGATION

ALTERNATIVE 2
NORTH DIKE CREST ELEVATION 5457.0
EAST DIKE CREST ELEVATION 5446.5

DRAWING
SHEET 1 OF 1 SHEETS

DWG: Z:_CURRENT_PROJECTS\EDAW\17445.00\1000\(2d\DESIGN\CREST EL 5457\CONCEPTUAL-DIKE-5457-PLAN.dwg Layout Name: Layout1 - Plotted by: Isenbuch, George Date: 12/11/2008 - 9:21 AM
XREFS: G-BD - C-SV - C-RP - C-HA-EL5457 IMAGES: GlobeXplorer_3.jpg - BOYLE_Mono.jpg -

Memo

Date:	May 13, 2016
Project:	Chatfield Storage Reallocation Project
To:	Brian Murphy, P.E. CDM (PgM)
From:	P. Paul Perri, P.E. HDR (RM2)
Subject:	*Gravel Pond Pervious Dike Preliminary Design*

Introduction

The Gravel Pond and Chatfield Reservoir currently have a small difference in normal maximum water surface elevation. The current normal maximum water surface elevation for Chatfield reservoir 5,432, while the Gravel Pond normal maximum water surface elevation is approximately 5,440 to 5,441 based on current topography. Implementation of the CSRP raises the Chatfield normal water surface elevation to 5,444. The Technical Memorandum from Boyle/AECOM dated December 18, 2008, included in the FR/EIS, presents a pervious dike and foundation as the preferred alternative to maintain the Gravel Pond as a separate body of water from Chatfield reservoir. The attached Boyle/AECOM Memorandum includes the following recommendation that "seepage and stability of the pervious dike be further analyzed and evaluated". As part of our preliminary design, HDR focused on the seepage considerations of the design as it is directly related to the stability of the dikes.

Preliminary Design

In preliminary design, HDR advanced the pervious dike of the north and east dike presented in the Boyle/AECOM memo. The primary intent of the north and east dikes is to provide an embankment to raise the existing roadways and provide a level of separation between the Gravel Pond and Chatfield Reservoir at elevation 5,444. The pervious dike concept was introduced to provide a more rapid response in the Gravel Pond water level as a result in rising water levels in Chatfield reservoir. Further evaluation of the pervious dike concept has determined that there is no net benefit of a pervious dike to maintain current water elevation, quality, clarity or an in kind design consideration in the Gravel Pond for the following reasons:

1. During current normal maximum operating condition, the Gravel Pond is approximately 8 feet higher than the Chatfield reservoir. Under this condition the water that feeds the Gravel Pond is from sources that upstream and adjacent to the Gravel Pond and not from Chatfield reservoir.

2. The additional hydraulic condition introduced through the inclusion of the pervious dike concept would result in water level fluctuations in the Gravel Pond not previously experienced. Currently, the Gravel Pond maintains a static water level between elevation 5,440 and 5,441. This has been a sufficient water level to meet the many recreational activities in the Gravel Pond. HDR is not aware of any need or interest to raise the water surface in the Gravel Pond to 5,444 as the Chatfield reservoir raises or to have the Gravel Pond level drop below elevation 5,439 as the Chatfield reservoir recedes.

3. Maintaining the lack of a hydraulic connection between the two bodies of water during the normal operating conditions maintains a consistent source of water, with a known quality and clarity, to the Gravel Pond.

Recommendation

Based on our preliminary seepage analysis, HDR recommends refining the dike design from the FR/EIS. HDR has shown above that the there is no net benefit of a pervious dike to maintain current water elevation, quality, clarity or an in kind design consideration in the Gravel Pond.