ACHIEVING REDUCED-COST WET WEATHER FLOW TREATMENT THROUGH PLANT OPERATIONAL CHANGES

Raymond R. Longoria, P.E., BCCEE1, Patricia Cleveland2, Kim Brashear, P.E.3
1Freese and Nichols, Inc.
1701 North Market Street, Suite 500
Dallas, Texas   75202

2Trinity River Authority of Texas
3Mehta, West, Brashear Consultants

ABSTRACT

Despite documented I/I reductions in the collection system1, the dynamic hydraulic model for the Trinity River Authority of Texas’ (TRA) Central Regional Wastewater System (CRWS) predicted an increase in the $Q_{2-HR \text{ PEAK}}/Q_{ADF}$ ratio at the WWTP from 2.5 to 3.30.2 The 2.5 ratio historical value was known to be artificially low, the result of unintended in-line storage created by hydraulic bottlenecks in the collection system. The 3.30 ratio is the year 2020 predicted value derived from the hydraulic model. This assumes the completion of the scheduled collection system improvements intended to remove the bottlenecks.

TRA intends to implement the collection system improvements and to treat all wastewater flows at the CRWS Wastewater Treatment Plant. The improvements recommended to handle the projected 3.30 ratio peak flows included 1) wet weather treatment facilities and 2) additional final clarifiers. Capital cost of the improvements to treat the peak flow was estimated at $21.1 million.3 The wet weather treatment facilities – High Rate Clarification - have been deferred pending final regulations/policy by the U.S. Environmental Protection Agency (USEPA) with regard to blended flows and the preparation of additional technical and economic data by the Authority. The final additional final clarifiers were budgeted for construction in 2010.

The Authority began investigating operational modifications at the plant to allow CRWS to handle increased peak flow until either or both of the planned improvements could be brought on line. The two operational modifications determined most feasible were the addition of step-feed capability for all of the secondary treatment basins and conversion of the existing in-line equalization basins to off-line peak storage basins. This paper describes these operational changes, the quantification of the increased peak flow capability of the CRWS plant and the associated capital cost reduction of $6.2 million.

KEYWORDS

Wet weather flow management, operational changes, step-feed, capital cost reduction
INTRODUCTION

The Trinity River Authority of Texas is a political subdivision authorized by the State of Texas to provide a variety of services in the Trinity River basin including planning, construction and operation of wastewater treatment facilities. The CRWS Wastewater Treatment Plant is the flagship facility of the Trinity River Authority of Texas, serving 23 customer cities in the Dallas/Fort Worth Metroplex depicted in Figure 1.

Figure 1

With an estimated population equivalent of 1.41 million persons the plant is permitted to discharge 162 MGD (Average Daily Flow) and 405 MGD (2-hour peak flow) with a 7/15/(2/4)/6 – CBOD/TSS/NH3/DO effluent quality set, although the plant historically has discharged a much better quality effluent. CRWS was constructed in multiple phases with the most recent being the completion of the Phase I/II Expansion in 1976 and the Phase III expansion in 1993. The phased expansions inclusive of the master planned improvements through site build-out (Phase V) are presented in Figure 2.
The current design flows and projected flows through Phase V are presented below in Table 1. The hydraulic model indicated an increase in the $Q_{2-H\text{, Peak}}/Q_{ADF\text{, ratio}}$ to a maximum of 3.30 and a maximum $Q_{2-H\text{, Peak}}$ of 623 MGD. The initial increases in the peak flow ratio result from the scheduled improvements in the collection system that are to be phased in between now and 2020 to eliminate the hydraulic restrictions. Despite the anticipated benefits of the Inflow/Infiltration improvements that the Authority and its customer cities have committed to implement each year between now and then, the impact of the removal of the hydraulic restrictions overcomes those reductions. The maximum peak ratio of 3.30 occurs in the year 2020, the design year for the Phase IV Improvements. All of the hydraulic restrictions will be removed by that year and the continuing I/I improvements are projected to produce a subsequent decrease in the peak flow ratio. The projected peak flow for Phase IV ranges from 594 to 623 MGD. The projected peak flow for Phase V ranges from 628 to 657 MGD.

The varying flows used by the Authority for planning are a function of whether the higher, more conservative State of Texas population projections approach or the less conservative, lower recent historical trend projections are used. For the facility design the higher population flows are used but for implementation planning (timeline for phasing of improvements) the lower recent historical flows are applied. For the plant facilities, inclusive of the improvements for handling peak flows and this paper, the 623 and 657 MGD values will be used for Phase IV and V, respectively.
Table 1. CRWS Raw Sewage Flow Projections

<table>
<thead>
<tr>
<th>Design Year</th>
<th>Q\textsubscript{ADF}</th>
<th>Q\textsubscript{ADF}</th>
<th>Q\textsubscript{2-H PEAK}</th>
<th>Q\textsubscript{2-H PEAK}</th>
<th>Q\textsubscript{2-H PEAK}/Q\textsubscript{ADF}</th>
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<tr>
<td></td>
<td>Historical</td>
<td>Population</td>
<td>Historical</td>
<td>Population</td>
<td>Historical</td>
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<tr>
<td>Current Design Flow</td>
<td>162.00</td>
<td>-</td>
<td>405.00</td>
<td>-</td>
<td>2.50</td>
</tr>
<tr>
<td>Current Flow (2002)</td>
<td>138.85</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2020 (Phase IV)</td>
<td>180.00</td>
<td>189.14</td>
<td>594.00</td>
<td>623.00</td>
<td>3.30</td>
</tr>
<tr>
<td>2040 (Phase V)</td>
<td>223.00</td>
<td>232.58</td>
<td>628.00</td>
<td>657.00</td>
<td>2.82</td>
</tr>
</tbody>
</table>

PROBLEM STATEMENT

A major process limitation at the CRWS is the marginal ability of the secondary treatment facilities to handle the 2-hour peak flows. Accordingly a critical facility process improvement identified for the Central Regional Wastewater System Wastewater Treatment Plant was the need to increase the Q\textsubscript{2-H PEAK} capacity from the current 405 MGD rating to 623 MGD, the peak flow capacity required for the Phase IV Expansion.

Phased improvements were developed in the CRWS Phase IV Master Plan to provide the required capacity utilizing wet weather treatment facilities (high rate clarifiers) and additional final clarifiers. A change in the prerequisites for permit approval of wet weather treatment facilities altered the original schedule of implementation to a yet undetermined date. Additionally, other CRWS facility needs with higher priorities than the additional final clarifiers would delay those improvements to beyond 2010. The Authority contracted with Freese and Nichols, Inc. to identify and develop alternate approaches to add peak flow treatment capacity.

The Authority’s goal was to identify operational changes at the CRWS WWTP that could be implemented quickly and economically and would provide adequate peak flow capacity until the long term improvements – wet weather treatment and additional final clarifiers – could be permitted and constructed.

The specific objective of the study was to evaluate the following two approaches:

- Increase peak flow capacity by providing step-feed to all of the secondary treatment basins;
- Increase peak flow capacity by optimizing the use of the existing equalization basins.

These approaches had been identified by the Authority staff and the CRWS Phase IV Project Design Team led by Freese and Nichols, Inc. in previous work.\textsuperscript{4}
ANALYSIS

The Authority commissioned an engineering report *CRWS Phase I&II Equalization Basin and Process Evaluation Final Report*, (August 2005) to evaluate the feasibility of both operational modifications, step-feed and optimized equalization basin operation, and develop conceptual designs and opinions of probable construction cost for each.

Step-Feed Modifications

The marginal ability of the secondary treatment facilities to handle the 2-hour peak flows resulted from the original facility design concept. When completed in 1976 the Phase I and II facilities were allowed, by permit, to pump primary clarifier effluent around secondary treatment during times of excess wet weather flows (whenever flows exceeded a \(2.5 \frac{Q_{2-HR \, PEAK}}{Q_{ADF}}\) ratio). Accordingly, the Phase I/II secondary treatment facilities were designed assuming this ratio. Flow in excess of this amount went directly to disinfection. The practice of pumping around the original Phase I&II secondary treatment units is no longer allowed and was discontinued when the new Phase III facilities came on line in 1993. This change caused and will have an increasing potential to cause more frequent operational problems in the Phase I/II facilities, including solids washout and poor quality secondary effluent to the tertiary filters.

Phase III was designed to allow for step-feed during peak flow events. Step-feed has the advantage of not overloading the aeration basins during a wet weather event because the flows are limited to only the last section of the aeration basins. The excess wet weather flows, up to 100 MGD, are routed via an overflow launder to the last third of the aeration basins (referred to as the C Section). Done for reasonably short periods of time – consistent with 2 hour peak flow events – the Phase III facilities have not had the referenced operational problems and maintained acceptable secondary effluent quality to the filters. The implementation of step-feed for the Phase III facilities was relatively easy, in that it involved new construction in an area of the plant with minimal below grade conflicts and the final clarifiers were specified with a deeper side water depth (SDW) of 15 feet versus 12 feet. Conversion of the Phase I&II final clarifiers was not considered during the previous expansion because the hydraulic restrictions in the collection system did not warrant more than what was provided in the Phase III new construction.

Although the installation of piping/valving to step-feed the peak flow to the Phase I&II aeration basins, similar to what was done in Phase III, would be complicated by the above and below grade conflicts, it was a proven approach and could be implemented quickly and economically. Because of the shallower final clarifier SWD it was anticipated that the original facilities could not handle the 100 MGD that the newer facilities were capable of handling. A proportional solids flux loading rate approach suggested that the original facilities could handle an estimated 70 to 80 MGD. An illustration of the piping and valving to accommodate the step-feed to the original plant is given in Figure 3.
Optimized Equalization Basin Operation

Optimization of the existing equalization basins (EQB’s) was focused around conversion of the basins from in-line equalization to off-line storage. In-line equalization refers to the current practice where all flow is routed through the partially full EQB and flow control is on the discharge side. Off-line storage refers to peak flow being routed to storage in an empty basin not in the normal flow path. This only would occur when elected by plant staff and flow control is on the inlet side of the basin. Although the existing basins operated in in-line equalization mode were believed to provide benefit in terms of equalization of peak flows, this had never been quantified. It was also believed that in most situations the equalization benefit was minimal because of lack of ability to use all of the available basin volume since flow was controlled by flow control valves (FCV’s) on the discharge side. Conversion of control to the influent side would allow greater benefit in that plant staff could consistently rely on all of the available basin volume.

Although the EQB’s have been used as in-line flow equalization for many years, that was not their original intent. The EQB’s are located between the primary clarifiers and the aeration basins and were designed to equalize the normal diurnal organic loading to the secondary
treatment units\textsuperscript{4}. Consequently, the basins are relatively small, with a combined storage of 22.2 MG, which is less than 5% of the 24-hour peak flow. The basins are in-line with the flow path with FCV’s limiting the discharge rate and no control on the inflow to the basins as illustrated in Figure 4. Given the small size of the basins and the uncontrolled inflow it was believed that reduction of the peak flow across the basin was small and would grow smaller when the collection system bottlenecks were removed.

![Figure 4](image)

**IN-LINE EQUALIZATION**

It was hypothesized that a change to off-line storage as shown in Figure 5 would yield a greater reduction of peak flow across the basin. Valving would be added before and after the equalization basin that would be normally closed (N.C.) and EQB diversion piping added with a valve that is normally open (N.O.).

![Figure 5](image)

**OFF-LINE STORAGE**

**Methodology.** The approach used to develop the findings and recommendation on whether to continue operation of the EQ Basins as in-line flow equalization or change to off-line peak flow storage included two key steps. The initial step was to document the design, historical and projected flows and hydraulics to the EQ Basins and utilize the flow data and hydraulic data to determine the current effectiveness of the EQ Basins to equalize peak flows and to estimate the effectiveness of the basins for off-line peak flow storage. If the off-line storage had unacceptable effectiveness in reducing the impact of the peak flows on the secondary treatment system it would no longer be considered. If it provided comparable or better effectiveness, then the second step was to determine for both approaches the impact of issues previously noted. It is
assumed that if the results of the evaluation for Phase I and II effectively change the operations of the EQ Basins to off-line peak flow storage, then Phase III EQ Basins will change as well.

Flows and Hydraulics. The CRWS plant is permitted to discharge 162 MGD of annual average flows and up to 405 MGD of peak 2-hour flow. The EQ Basins in Phase I and II are approximately half the size of the EQ Basins in Phase III. Therefore, based on the existing flow split, each EQ Basin in Phase I and II and Phase III can handle approximately 20 and 40 MGD respectively. The same flow split is routed into the corresponding aeration basins. Each Phase I and II has three aeration basins while Phase III has six aeration basins. The following Table 2 shows the flow distribution between basins.

Table 2 – Current Phase I, II and III Flows to EQ Basins and Aeration Basins

<table>
<thead>
<tr>
<th>CRWS Phase</th>
<th>Equalization Basin</th>
<th>Aeration Basin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of Basins</td>
<td>ADF (MGD) Total</td>
</tr>
<tr>
<td>I</td>
<td>2</td>
<td>40.5</td>
</tr>
<tr>
<td>II</td>
<td>2</td>
<td>40.5</td>
</tr>
<tr>
<td>III</td>
<td>2</td>
<td>81</td>
</tr>
</tbody>
</table>

Existing piping configurations require that all flows from the primary clarifiers be routed through the EQ Basins before entering the Aeration Basins. The potential changes to off-line peak flow storage operation for the EQ Basins will require some piping modifications to route flows around the EQ Basins directly into the Aeration Basins.

EQ Basin Evaluation. It was believed the change of operation of the EQB’s to off-line storage would reduce the peak flow out of the basins sufficiently to allow TRA to eliminate the need to construct some or all of the additional secondary clarifiers. Although cost was a key criterion, the evaluation also considered the following issues:

- Impacts to the liquid and solids processes (positive and negative)
- State of Texas permit changes associated with any change of the EQB’s use
- Odor
- EQB O&M
- Operational reliability
- Required Infrastructure Modifications

Pertinent issues related to current operation of the EQ Basins to be included in the evaluation are as follows:

1. Incorrect sizing of existing effluent piping from EQ Basins 1-4 constricts outflow from the EQ Basins making it impossible to maintain reasonably low levels at low flow periods.
2. Normal continuous flow of primary clarifier effluent through the EQ Basins and depth of water in the EQ Basins produce an uncontrollable odor source. Operation of the aspirating mixers to keep the solids in suspension exacerbates the odor issue.
3. Despite the aspirating mixers organic solids will accumulate in the EQ Basins.
4. Lack of control of wet weather inflows to the basin make it difficult to have positive control of the water depths in the basins increasing the risk of structural failure.
5. Lack of back-flow control creates a condition which could result in the basins emptying to the plant site if there is a failure in the primary clarifier header.
6. The equalization/storage volume available in all the existing EQ Basins is small, representing less than 5% of the conventional 24-hour peak flow.

A review of the current operation of the basins, future flows and future operation goals, indicates three available alternatives for these existing basins:

1. Continue current operation as in-line flow equalization.
2. Convert the system to use the basins for off-line peak flow storage.
3. Eliminate the use of the basins for any form of equalization or storage.

Discontinuing use of the basins was not considered to be consistent with TRA objective of controlling peak flows to the secondary treatment units as well as fully utilizing existing facilities and was eliminated as a viable alternative.

Hydrograph Development. The standard approach to quantify the difference would be to develop hydrographs routing current and projected inflow through the EQB’s under both scenarios to determine the hydrograph to the secondary treatment facilities. Unfortunately there was no historical flow data in/out of the EQB’s and limited potential to obtain data since there is no reliable upstream flow meter and the current peak flows into the plant are unrepresentative of the future conditions without hydraulic bottlenecks.

The approach undertaken to develop the hydrographs uses serendipitous flow data obtained in June 2004 when an extended peak flow event allowed the effluent flow meter to register flows representative of future inflows to the EQB’s. The major steps in developing the hydrographs included:

- Development of the base peak flow hydrograph from the hydraulic model for current, 2010, 2020, 2030 and 2040 flow scenarios.
- Comparison of the base hydrograph to the shape of the June 2004 peak flow hydrograph
- Development of a theoretical future inflow hydrograph by superimposing multiple occurrences of the base peak flow hydrograph at assumed frequencies and magnitudes to reflect the shape of the June 2004 hydrograph
- Creation of the discharge hydrographs for current, 2010, 2020, 2030 and 2040 flow scenarios to reflect the dampened flows to the secondary treatment basins.

Routing the flows through in-line equalization and off-line storage in the EQBs requires development of the base hydrograph. In the TRA CRWS Phase IV Infiltration/Inflow Assessment dated May 2004, Black and Veatch presented several hydrographs with influent flow modeling based on population growth projections flows. These previously developed hydrographs identifying flow coming into the TRA-CRWS wastewater treatment plant were used.
as the base hydrographs. These hydrographs were developed through models for current (2002), 2010, 2020, 2030 and 2040 flow scenarios based on population growth projections, improvements to the collection system, additions to the collection system, and major interceptor improvements.

The base hydrograph is a 48-hour hydrograph based on average daily flow to the plant impacted by the design storm on the collection system. Figure 3-1 shows the hydrographs for each of the design years. There are many ways to examine hydrographs and the terminology is just as varied. In this case, the 2-hr peak flow is considered the flow below the top of the curve constituting 1-hour on either side of the peak. Similarly the 8-hr peak flow and 24-hr peak flow represent that flow beneath the curve to 4-hr and 12-hr intervals before and after the peak point on the base hydrograph curve. All of these hydrographs show a typically “bell-curve” shape with peak flows entering the plant over a relatively short period of time. Through further assessment, an additional 5-day hydrograph curve was also developed for this review.

Discussions with the Authority staff indicated that, although the flow quantities developed and used for the standard hydrographs are useful in design, the observed flow characteristics into the plant are different. The flow generally rises and maintains a higher than average daily flow for 2 or more days (longer period of time). A review of historical flows during a period in the summer of 2004 that included significant wet weather events and no flow restrictions at the influent structure (constituting significant storage in the collection system) revealed a “typical” storm that was used as the basis for a 5-day event routing through and/or around the EQBs. A Theoretical event was developed based on the current flows, the storm and the future projections.

There are no flow metering points at the headworks or prior to the EQBs to precisely define the flow characteristics of that event. As such, the theoretical event is based on actual 2-hour effluent data from June 8 through June 14, 2004. The development of the theoretical event consisted of combining storm events (2002 influent hydrograph) with staggered start times and varying intensities to approximate the effluent hydrograph from the June 2004 data. Once this hydrograph series was developed, the sequence of storms was applied to the 2010, 2020, 2030 and 2040 projected hydrographs. The projected long-duration storm hydrographs were then routed through in-line equalization and through off-line storage to determine the respective effectiveness of the EQBs during these types of wet-weather events.

The results of both evaluations, for the standard hydrograph routing and the wet-weather long-duration storm event, indicated that in-line equalization offered very little peak flow reduction. This was expected since the EQBs were designed initially not for peak flow reductions but for diurnal organic equalization. When the flow is routed through the EQBs, there is very little volume allowed to dampen the peaks and this volume is used very early in a peak event. The size of the EQBs is simply not adequate for this type of equalization.

The evaluation indicated that, based on an off-line routing of a wet-weather event, a considerable reduction in peak flows can be experienced. The TRA-CRWS objectives include the positive control of flow routing within the plant. Based on this objective, the off-line equalization would be utilized during wet-weather events from which significant peaking is expected. Operators
would, as always, monitor the weather, rainfall, collection system and soil moisture indicators to identify when possible off-line equalization events may occur.

**EQ Basin Use Evaluation Results.** The use of hydrographs to model a peak flow event through an equalization basin is subjected to numerous variables and assumptions. By using conservative variables and reasonable assumptions, a close representative hydrograph of the actual wet weather event can be developed. The generated hydrographs indicate a trend that shows off-line storage use of the EQ Basins will provide better peak flow shaving compared to inline equalization. Any proposed change to a major process operation, such as the change from in-line equalization to off-line storage warrants a review of the potential impact to the downstream liquid and solids treatment processes. The potential impact at each of annual average flow, conventional (2-hour) peak and extended wet weather peak flows were reviewed.

The results from the hydrograph shown in Figures 6 and 7 suggests that during conventional peak flows the in-line equalization configuration can effectively reduce the peak to the secondary treatment by about 17 MGD and the off-line storage configuration by about 115 MGD.

**Figure 6**

![2020 Hydrograph - In-Line Storage](image)
This assumes that the hydrograph shown accurately reflects the pending storm flow event and TRA staff select the optimum time to begin the off-line storage. Both are significant assumptions. To reflect this, the peak reductions used in the evaluation for in-line equalization and off-line storage were assumed to be approximately one-half that amount or 10 MGD and 60 MGD, respectively. This provides a reasonable safety factor associated with the assumption. Conventional peak flow is the typical flow response to a single storm event observed over a 48-hour period which starts and ends at a flow equal to the ADF and at its peak is approximately 2.5 times ADF. However, during extended wet weather peak flows there is also no meaningful difference in flows to the secondary treatment in that the basins peak shaving or storage benefits would have already been committed. Similarly, the current operating strategy at CRWS also has no meaningful difference in flows to the secondary treatment during flows at or below the annual average daily flows.

These projected flows shavings would have a relevant process impact on the final clarifier and the advanced secondary treatment filters. The estimated peak 2-hour flow reduction of 60 MGD associated with off-line storage would support the elimination or deferment of the additional final clarifiers 4 of the 10 tertiary filters recommended in the CRWS Phase IV Master Plan. The tertiary filters recommended in the master plan are intended to provide additional redundancy and more reliable effluent quality consistency in anticipation of the addition of wet
weather treatment units at CRWS in the future. The flow reduction associated with the off-line storage corresponds to the rated capacity of 4 of the filters.

It should be noted that actually reducing the peak 2-hour flow the 60 MGD amount estimated requires the plant to effectively interpret and anticipate the pattern of peaking associated with each wet weather flow event and initiating the off-line storage operation. Additionally, because the wet weather treatment unit effluent will be higher in organics, ammonia nitrogen, and possibly solids, it is critical that, even during peak flow events, the effluent from the conventional train do not deteriorate. Therefore, it may be advisable to provide sufficient redundant filter capacity as a safety factor.

The estimated peak 2-hour peak flow reduction of 10 MGD associated with the in-line equalization operation of the EQ Basins does not affect the number of units recommended in the master plan or the operation of the downstream process units.

Findings of the evaluation with respect to the other key criterion to be considered in an overall decision to convert from in-line equalization to off-line storage are as follows:

**Solids Loading.** Operation of the EQ Basins in either in-line or off-line storage mode will not noticeably impact the solids flow or operation. These processes are more significantly impacted by 24-hour and annual average day loading changes. During wet weather events, the first flush, or portion of the wet weather flow that typically contains the highest solids levels will be routed directly to the aeration basins and downstream treatment units. The stored flows will typically be the more dilute flows associated with later peaking. Only minimal operational change, if any, is anticipated in the solids loading.

**Odor Control and Mitigation.** The modifications in operation of the EQ Basins from an on-line to an off-line wet weather storage mode will positively impact the odor situation at the CRWS plant. Ceasing to operate the EQ Basins on a daily basis will reduce the fugitive emissions released from the surface of the EQ Basins on a continual basis. There are no existing plans to control these odors for they tend to be localized rather than perceived off-site. The primary issue with regard to odor control at the EQ Basins is to insure that when they are taken off-line after use in a wet weather storage mode, they are emptied and washed down to eliminate the stagnation of sludge in the bottoms of the basin. Sludge and/or wastewater collected in the bottom of the basins will produce significant foul odors.

**TPDES Permitting Issues.** The amendment application currently before the TCEQ does not rely on the operation of the EQ Basins as a critical part of the plant’s treatment process. Use of the EQ Basins in either on-line or off-line wet weather storage does not affect the permit application. Reducing the projected peak 2-hour flow does require resubmitting the amendment application with the new flow value.

**Operation and Maintenance.** The operations and maintenance of the EQ Basins and related treatment structures will vary depending on the EQ Basins use, step feeding procedures and the amount of flow entering the treatment plant. Modifications to the EQB influent splitter box will provide the flexibility to step feed at any time during any flow scenario. Since the EQ Basins are recommended to be used as off-line storage, it is assumed that the step feed process is preferred.
during a wet weather flow event before storage in the EQ Basins. Depending on the operational scenario opted by plant staff, the influent to the EQ Basins and/or step feed can either be primary effluent of future High Rate Clarifier (HRC) effluent. The unit operations upstream of the EQ Basins do not affect the use of the EQ Basins or the procedures for handling wet weather flows downstream of the primary treatment. The modifications necessary to convey flows from upstream processes to the EQ Basins will be separately evaluated.

**Proposed Infrastructure Modifications.** Based on the recommendation of changing the EQ Basins to operate as offline storage basins, several structural and piping modifications are necessary to accommodate the changes. Step feed piping is recommended for Phase I and II if the EQB’s are to be operated as off-line storage. The step feed piping allows for operational flexibility especially during wet weather flow events. It was recommended that the step feed piping configuration be similar to that in Phase III.

Taking the EQ Basins offline will require that all primary clarifier effluent be routed around the EQ Basins and directly into the aeration basins. New direct feed piping is recommended to route primary effluent directly to the aeration basin influent boxes. The direct feed pipes will include flow meters to allow for flow monitoring and measurement.

Additionally, the EQ Basin influent splitter boxes for all three Phases will require modification to allow the isolation of the EQ Basins during normal flows. In the existing Phase III configuration, step feed is only possible after the EQ Basins 5 and 6 are full and overflowing into the step feed influent launder. For the proposed EQ Basin operation, modifications to the influent splitter boxes are necessary to allow step feed to occur prior to storing flows in the EQ Basins. In Phase I and II, the proposed step feed piping will begin at the EQ Basin influent splitter boxes. Modifications to these boxes will allow for feeding the step feed piping and the EQ Basins.

**Findings and Recommendations**

The two hydrographs presented in the evaluation section calculated peak flow dampening for the year 2020 flows by in-line equalization and off-line storage. The stated hypothesis that the peak flow reduction at CRWS from in-line equalization was minimal was correct. The peak flow reduction from off-line storage is shown to be almost seven-fold greater (115 MGD vs. 17 MGD) than what occurs with in-line equalization. This greater quantity of peak flow reduction coupled with the addition of step-feed capabilities at the Phase I&II aeration basins would eliminate the need for construction of the two proposed new final clarifiers and 4 of the proposed tertiary filters.

The cost for these modifications is $1.6 million or $6.2 million less than the conventional approach of constructing the additional final clarifiers and tertiary filters. In addition to being lower cost it was judged to be as good as or better than the conventional approach when compared to the non-cost criteria especially the reduced odor potential and O&M requirements. TRA is implementing the modifications required to add step-feed capability to the Phase I&II aeration basins and converting all of the CRWS EQB’s to off-line storage by 2007.
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