# *Project Memorandum*

URS

To: Project File: Beale AFB WWTP

URS Project No. 17325861.50000

From: John Harrison

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Subject: Evaluation of Alternatives for Upgrade of the Beale AFB WWTP and LBD System

The following memorandum provides a record of the evaluation of alternatives for upgrading the Beale AFB Wastewater Treatment Plant (WWTP) and Land Based Discharge (LBD) system. Contained in the memorandum are the following Tables and Figures:

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# 1. Summary

A goal of the early study phase for upgrading the Beale AFB WWTP was to keep the total capital cost under $3 million. Therefore, only necessary improvements to the WWTP were considered. The WWTP upgrade project will include adding or improving denitrification, filtration, and disinfection. Improvements, changes and/or enlargement of the effluent disposal systems (referred to as land based discharge or LBD) were conducted by others as a coordinated effort with this evaluation of how to upgrade the wastewater treatment plant.

Two methods were initially studied for removing nitrate, these were: (1) converting the existing chlorine contact basin to a solids contact basin where denitrification could occur and (2) constructing a new denitrifying effluent filter. An initial evaluation showed that the use of a solids contact basin would require less capital and have nearly the same annual operating cost as denitrifying filters. The use of a solids contact basin was selected for removing nitrate nitrogen because of advantages for cost, ease of operation and flexibility.

The disinfection of effluent is another treatment step that requires change depending upon which discharge option is choosen (Hutchison Creek, land based discharge or recycled water). The initial evaluation of disinfection alternatives focused on producing effluent of reuse (Recycled or Title 22 water) quality. This evaluation showed that chlorination/dechlorination would be considerably less expensive than using UV disinfection. However, a comparison of disinfection methods using sizing criteria for land based discharge and Hutchinson Creek only (no recycle water) showed that UV disinfection would have a cost advantage for capital, but that annual operating costs would be higher than using chlorination/dechlorination.

To make clear how to best upgrade the Beale AFB WWTP, two complete project scenarios (Projects A and B) were developed. This final comparison allowed an evaluation of how choices in denitrification, disinfection and filtration impact each other. The first step in each scenario consisted of developing a "Basic Upgrade" design to improve effluent so that land based discharge can occur without creating an adverse impact to the environment. A second step (Bid Option 1) was then added to each scenario to provide tertiary treatment suited for producing recycled water. Finally, a third step (Bid Option 2) was added to each scenario to provide advanced tertiary effluent suitable for discharge to Hutchinson Creek. Bid Option 2 also provides increased reliability/redundancy.

Project A's basic upgrade included retrofitting the existing chlorine contact basin to a solids contact basin for denitrification and constructing a new chlorine contact basin for disinfection purposes. Key bid options for Project A include adding effluent filtration and a chemical clarifier.

Project B's basic upgrade included constructing a new solids contact basin and adding sufficient UV disinfection to accommodate all but peak flow events. The existing chlorine contact basin would be maintained for peak flow events or for future use to produce Recycled Water. Key bid option for Project B include adding effluent filtration and a chemical clarifier.

A final recommendation was made to proceed with the Concept Design of Project B as the "Apparent Best Upgrade" of the existing Beale AFB WWTP. Project B's basic project includes solids contact and UV disinfection as the Basic Project that is sufficient for improving the effluent

for land based discharge. Bid Option 1 will add effluent filtration that can produce tertiary effluent suited for a Recycled Water System. Bid Option 2 will add a chemical clarifier that can produce advanced (polished) tertiary effluent suited for discharge to Hutchinson Creek. The chemical clarifier constructed in Bid Option 2 will serve as a redundant secondary clarifier in order to increase reliability.

# 2. Initial Alternative Evaluations

Beale AFB has proposed to utilize land application as the primary method for disposing of treated domestic wastewater and air stripper effluent. Improvements to the land application (otherwise known as land based discharge) system are being developed by Earth Tech under separate contract. Details of these developments are found in:

- Earth Tech, 2007. *Draft Engineering and Operations Planned for Land based Discharge System*; and
- Earth Tech, 2007. *Preliminary Design Drawings – Tailwater Return System.*

Modifications to the land based discharge systems can have a significant effect on the level of treatment required at the wastewater plant. For planning purposes in this Customer Concept Document, the "Basic" upgrade of the Beale AFB WWTP was directed at land based discharge. Alternatives that would allow discharge to Hutchinson Creek or for recycled water were included as bid options to the basic upgrade project.

The following options were considered to achieve both the required discharge limits and meet the established project goals for the Beale AFB WWTP Upgrade.

## DENITRIFICATION

A denitrification process will be added to the existing WWTP treatment scheme. This additional treatment will allow total nitrogen values to be reduced within ranges necessary to prevent adverse impacts to groundwater.

Option 1 – Solids Contact: The existing CCB will be converted to a solids contact basin with provisions for a methanol (or other carbon source) addition as illustrated on Figure 1. Methanol will undoubtedly be required because of the low strength wastewater and highly oxidative state of the trickling filter underflow. A return secondary sludge (RSS) submersible pump station will be added to return settled biological solids to the new solids contact basin (converted existing CCB). Floating mixers will be installed in each of the three existing chambers. The conversion to solids contact should be relatively low in cost since the existing CCB is in a good location and is of adequate size.

A portion of the secondary effluent will be split off and pumped to effluent filters. Both filtered effluent and unfiltered effluent would then be disinfected prior to disposal. A description of disinfection alternatives will be given later in this section.

The solids contact alternative splits off a portion of effluent and treats a relatively modest portion of the flow in a tertiary (effluent filtration/new disinfection) system designed to achieve the production of recycled water that meets the California Title 22 regulations or meet future discharge requirements to Hutchinson Creek.

The advantage of the Solids Contact Option is that denitrification is separated from filtration, resulting in a less complicated system than combining both nitrate removal and filtration in the

same unit. Another advantage of solids contact is that the effluent filters may cost less than deep bed units.

Option 2 – Denitrification Effluent Filter: The denitrification effluent filter alternative combines methanol addition with the use of deep bed continuous backwash upflow (CBU) filters as illustrated on Figure 2. Because both denitrification and filtration are combined in the same unit, a more conservative hydraulic loading is used on the filters than would otherwise be required. A computerized control package will be included to control the amount of methanol so that overdosing does not occur. The addition of methanol is necessary to provide an anoxic (no free oxygen) state and environment that will cause bacteria to remove nitrate. It will also be necessary to re-aerate denitrified effluent after filtration but prior to discharge.

An advantage of the denitrification Effluent Filter Alternative is that the existing CCB will now be available for a reuse water storage basin. A disadvantage is that a majority of the secondary effluent must be treated by the denitrification filter. Since LBD is still the primary means of effluent discharge, peak flows will bypass the tertiary treatment system so that unit sizes may be reduced. Because the land application systems are preceded by more than 100 days of hydraulic storage, the combined effluent will meet permit requirements even though peak flows bypass the denitrification step.

## FILTRATION

An effluent limitation of 10 mg/L BOD/TSS can not be reliably achieved unless effluent filtration is available. When secondary effluent turbidity exceed 5 to 7 NTUs, it may be necessary to precede the filters with chemical addition to achieve a final effluent turbidity of less than 2 NTUs.

There are numerous types of filters available to remove suspended solids and reduce turbidity. Currently, commonly selected filters at WWTPs are often either granular media or cloth (disk) filters. Membrane (microfiltration) filtration similar to that used in treating drinking water is also available, but tends to be more costly than other types of filter units.

Two of the more popular filter devices for producing recycled water are the CBU filter and the fuzzy filter (hereafter referred to as high-rate filters). High rate filters can be loaded hydraulically (5 gpm/square foot) at about two times higher than the rate of filters with reduced media depth or with filters that have limited solids carrying capacity. A benefit of the CBU type high-rate filters is that denitrification may be incorporated and its high solids carrying capacity may be a benefit when the chemical addition is incorporated into the filtration scheme.

Numerous other filters exist but may have limitations for treating effluent high in turbidity. Both traveling bridge filters and cloth (disk) filters have been successfully used to filter secondary effluents, which have low influent turbidity. The advantage of these low rate (2 gpm/square foot) filters is that they can be procured at a modest cost. However, unless turbidity in the trickling filter effluent is reduced by addition of the solids contact reactor and/or chemical flocculation , low rate filters may not achieve the required 2 NTU for recycled water or for discharge to Hutchinson Creek**.**

## DISINFECTION

Upgrading the disinfection system at the Beale AFB WWTP is most likely to be accomplished by the following:

1. Chlorination/dechlorination.
2. Ultraviolet (UV) radiation.
3. A combination of UV and chlorination/dechlorination.

One option to upgrade the disinfection system would be to construct a new disinfection system for chlorination/dechlorination. The new chlorination/dechlorination system will use the existing equipment for generating hypochlorite but would utilize a new basin, and new monitoring/control. Alternative means of dechlorination may be implemented. The new chlorine contact basin would be divided into channels with geometry and hydraulic retention best suited for achieving low total coliform and minimizing the required chlorine dose. Both the dechlorination step and the compliance monitoring/sampling would be moved to the end of the chlorine contact basin (rather than at the PAB). The formation of DBPs will be controlled by avoiding the production of free chlorine. Ammonia will be added to the effluent prior to introducing the hypochlorite solution. Assuring that the effluent to contains some $NH_4$ (< 2 mg/L) results in the formation a chloramine's rather than free chlorine. Chloramines greatly reduce the formation of THMs or other related DBPs.

Another option would be to achieve disinfection by use of UV radiation system. Converting to UV would lower effluent TDS and also eliminate issues associated with disinfection byproducts. However, capital cost for a UV system is likely to be relatively high in order to achieve a 2.2 most probable number (MPN) discharge limitation. Additionally, regulations by the California Department of Health Services require that UV equipment producing recycled water be subjected to rigorous on-site validation tests. This will add cost to already expensive UV equipment. UV validation testing and full equipment redundancy required for producing recycled water would not be required for discharge to Hutchinson Creek.

Another possibility is to use a combination of UV radiation and conventional chlorination/ dechlorination. With this scenario (Figure 1 and Figure 2) UV equipment would be utilized to disinfect the Title 22 recycle water or for discharge to Hutchinson Creek. A parallel system using conventional chlorination/dechlorination will disinfect flow discharged to the land based discharge systems not involving recycled water. The combined disinfection approach complicates monitoring and control. However, a combined system may result in reduced overall capital cost since disinfection needs can be tailor made to the disposal option.

# 4. Evaluation of Projects A and B

The answer to how best upgrade the Beale AFB WWTP varies depending upon which disposal option is selected.

Disposal Option 1: Disposal of effluent through land based discharge (LBD) could continue using the irrigation site and/or golf course. However, denitrification and additional irrigation land will be necessary to assure that there is no adverse impact of to groundwater. An increase or waiver in TDS limit will also be necessary to continue discharge to the irrigation system.

Disposal Option 2: Discharge to Hutchinson Creek will require additional treatment for removing $NO_3$-N, low turbidity and removal of other constituents that will become limiting on 1 April 2009 when stringent NPDES discharge limits become affective.

Disposal Option 3: Future development of a recycled water system will require the use of wastewater treatment technology similar to that needed for discharge to Hutchinson Creek. A disadvantage in developing a future recycled water system is that increased redundancy and reporting will likely be required. Extensive time will also be required to construct both the recycled water system and develop reuse customers/sources. An advantage with reuse through a recycled water is that there may be fewer permit limitations than those required discharge to Hutchinson Creek which is regulated with an NPDES permit.

Implementing an upgrade the Beale AFB WWTP can be done as a single project with bid packages that first focus on producing an effluent quality suitable for land based discharge. The improvements for upgrading the WWTP to meet land based discharge requirements will be necessary for any other disposal options which include discharge to Hutchinson Creek or to a recycled water system.

To give a clear picture of how best to upgrade the Beale AFB WWTP it is necessary to combine selected approaches to denitirification, disinfection, and filtration into a complete project. Evaluating based on a complete project basis is necessary because of the impact individual process choices have on each other. To provide the necessary complete comparison, two project approaches (Project A and B) to upgrade have been considered as described in the following report sections.

## PROJECT A – RETROFITTED BASIN AND NEW DISINFECTION SYSTEM

One approach (Project A) for upgrading the Beale AFB Wastewater Treatment Facility is illustrated in the concept schematic on Figure 3. Along with the basic upgrade for LBD two bid options will be included. The first bid option would allow facilities for a recycled water system to be constructed. The second bid option will provide both advanced tertiary facilities and also a redundant secondary clarifier (which presently is not available).

A unique feature of Project A is the conversion or retrofitting of the existing chlorine contact basin into a new solids contact basin. However, by retrofitting the existing basin, a new

disinfection system is required in the basic upgrade project. Since the Beale AFB would like to implement a recycled water program the new disinfection system must be chlorination system. This is because current regulations for disinfection of reclaimed water classified at "recycled" make the use of UV disinfection cost prohibitive. A drawback with Project A is the high capital cost of the basic project and continued use of chlorination/dechlorination which add TDS to the treated effluent. An advantage of project A is that there is a cost savings in retrofitting, rather than constructing a new solids contact basin. Project A - Retrofitted Basin and New Disinfection System, includes the following.

Basic WWTP Upgrade:

1. Recirculation Pump Station - construction of a new trickling filter recirculation pump station

2. Solids Contact Basin - conversion of the existing chlorine contact basin to a solids contact basin for denitirification

3. Return Secondary Sludge Pump Station –a new pump station to transfer settled sludge from the secondary clarifier to the solids contact basin.

4. Methanol Feed System –installation of a chemical feed storage tank and feed system to supply a carbon source for the denitrification process.

5. Disinfection Facility-a new chlorination/dechlorination basin configured in accordance with design standards necessary to reliably achieve low coliform counts.

Bid Option 1 – Tertiary Treatment:

1. Effluent Filter Pump Station-a lift station transferring either secondary or chemical clarifier effluent to the effluent filters.

2. Effluent Filters- two 2-disk cloth media filters will be installed to remove particulate solids.

Bid Option 2 – Advanced Treatment:

1. A new 60 foot diameter chemical clarifier that may serve as 1) a secondary clarifier, 2) a chemical clarifier (following the existing secondary clarifier), or 3) as a redundant (standby) secondary clarifier.

2. Enhanced Disinfection System-ammonia will be added/mixed with hypochlorite prior to chlorination by forming chloramines to reduce the production of disinfection by products.

## PROJECT B – NEW BASIN AND NEW DISINFECTION SYSTEM

Another approach (Project B) for upgrading the Beale AFB Wastewater Treatment Facility is illustrated in the concept schematic on Figure 4. Along with the basic upgrade for LBD two bid options will be included. The first bid option would allow facilities for a recycled water system to

be constructed. The second bid option will provide both advanced tertiary facilities and also a redundant secondary clarifier (which presently is not available).

A unique feature of Project B is that a new solids contact basin could be built rather then retrofitting the existing basin. When considering the potential hidden costs of retrofitting old units, and congested piping and utilities near the chlorine contact basin, a new approach may prove less costly. A new basin would also allow a new disinfection system to be included as a bid option rather than being required in the basic bid. Another interesting feature of Project B is that the existing chlorine contact basin could be utilized for disinfection of recycled water only. This would allow UV radiation to be installed as an alternative to chlorination/dechlorination. A drawback with of to the use of UV for disinfection is that annual electrical power costs may average nearly $60,000 (@ $0.15 per kWh). However, the cost of generating disinfection and dechlorination reagents would be eliminated for all but during peak flow events. More importantly UV disinfection will eliminate added TDS to discharge to LBD.

Basic WWTP Upgrade:

1. Recirculation Pump Station - construction of a new trickling filter recirculation pump station

2. Solids Contact Basin – construct a new contact basin for denitirification

3. Return Secondary Sludge Pump Station –a new pump station to transfer settled sludge from the secondary clarifier to the solids contact basin.

4. Methanol Feed System –installation of a chemical feed storage tank and feed system to supply a carbon source for the denitrification process.

Bid Option 1 – Tertiary Treatment:

1. Effluent Filter Pump Station-a lift station transferring either secondary or chemical clarifier effluent to the effluent filters.

2. Effluent Filters- two 2-disk cloth media filters will be installed to remove particulate solids.

3. Disinfection Facility-a new UV system would be installed to achieve a 2.2 MPN coliform limit. Flows in excess of 2.0 mgd would be bypassed to the chlorine contact basin for disinfection. Reclaimed water intended for reuse in a “purple pipe” system will also be further disinfected (after UV radiation) in the chlorine contact basin.

Bid Option 2 – Advanced Treatment:

1. A new 60 foot diameter chemical clarifier that may serve as 1) a secondary clarifier, 2) a chemical clarifier (following the existing secondary clarifier), or 3) as a redundant (standby) secondary clarifier.

# Figures

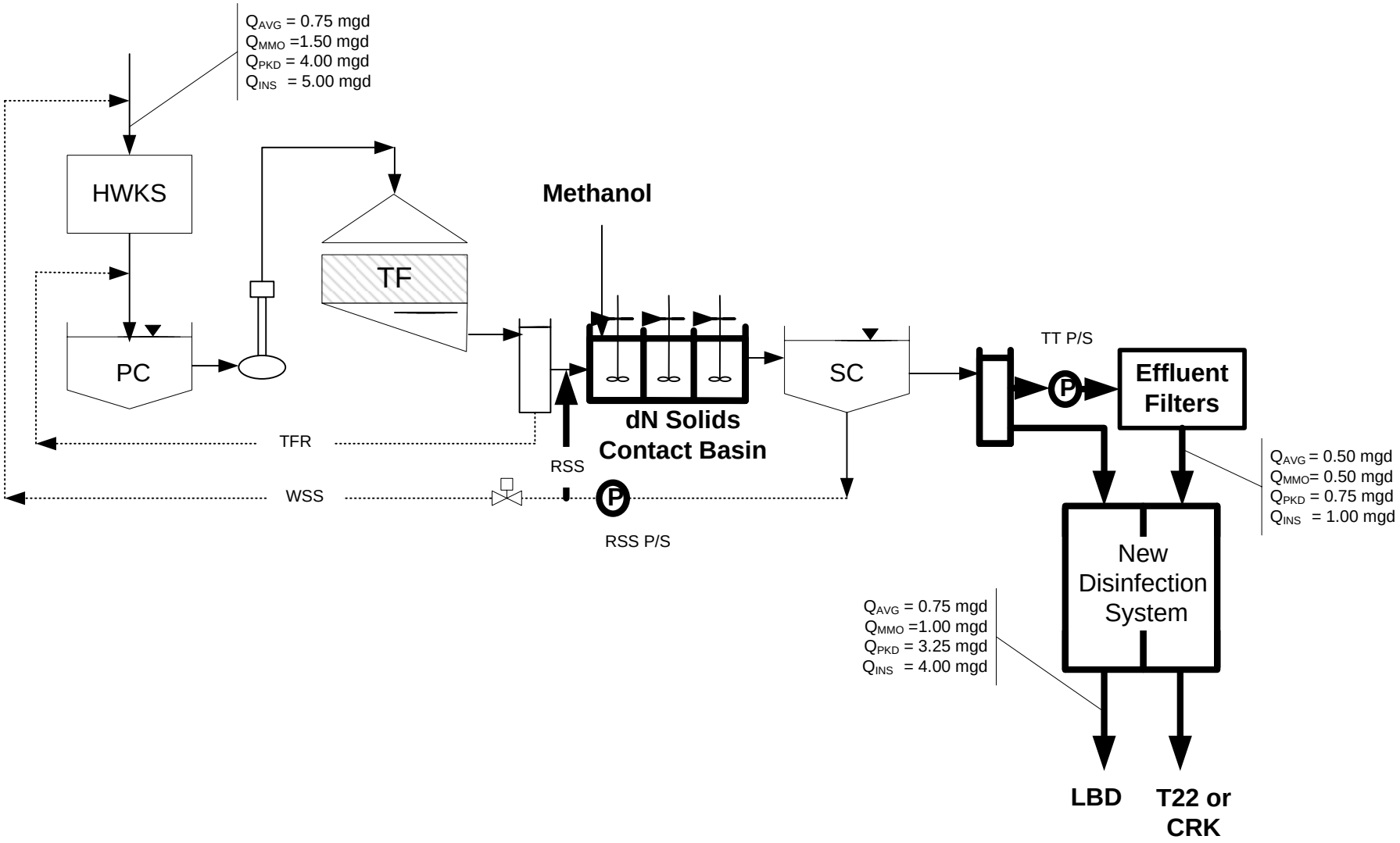



Figure 1: Flow Schematic – Solids Contact Upgrade

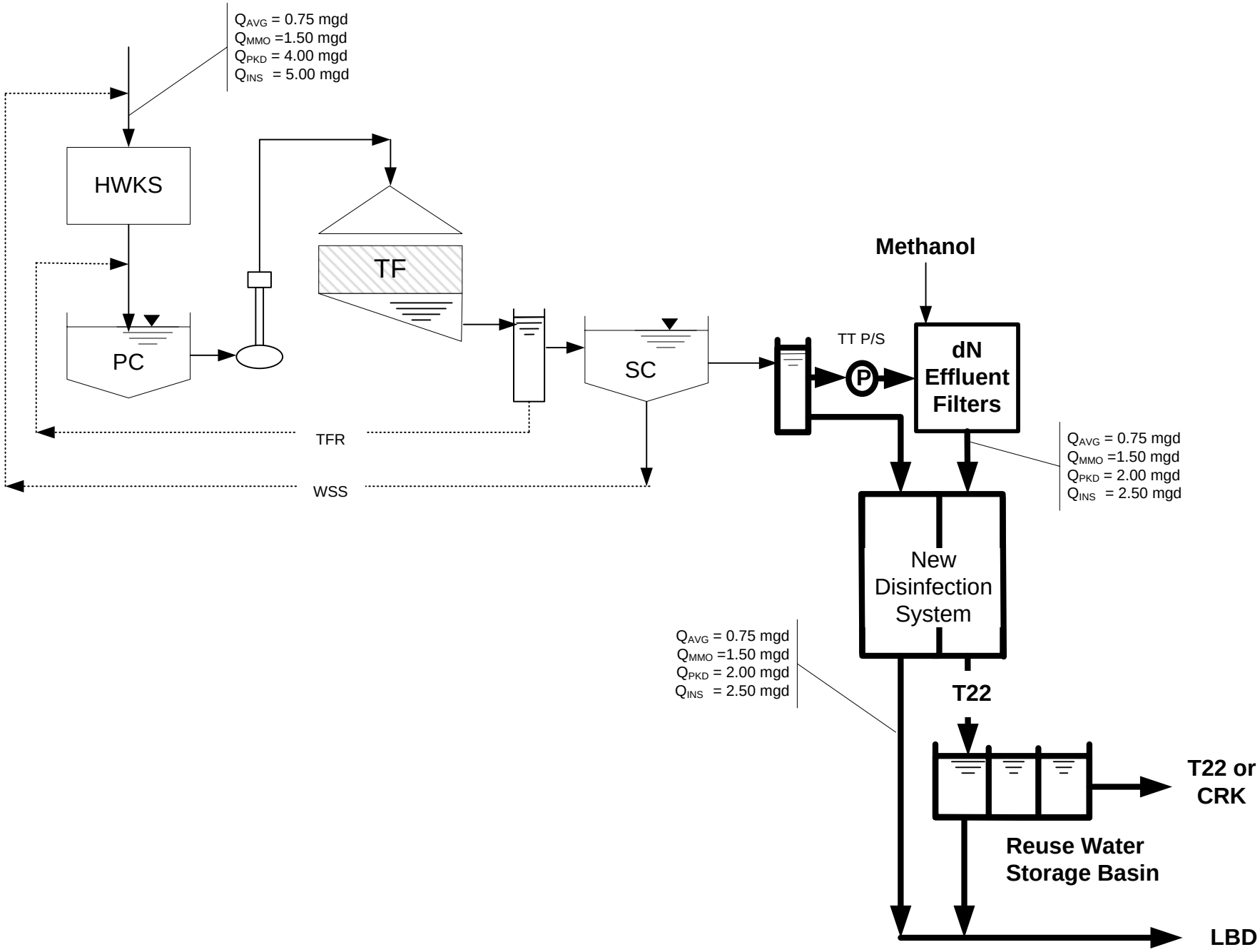
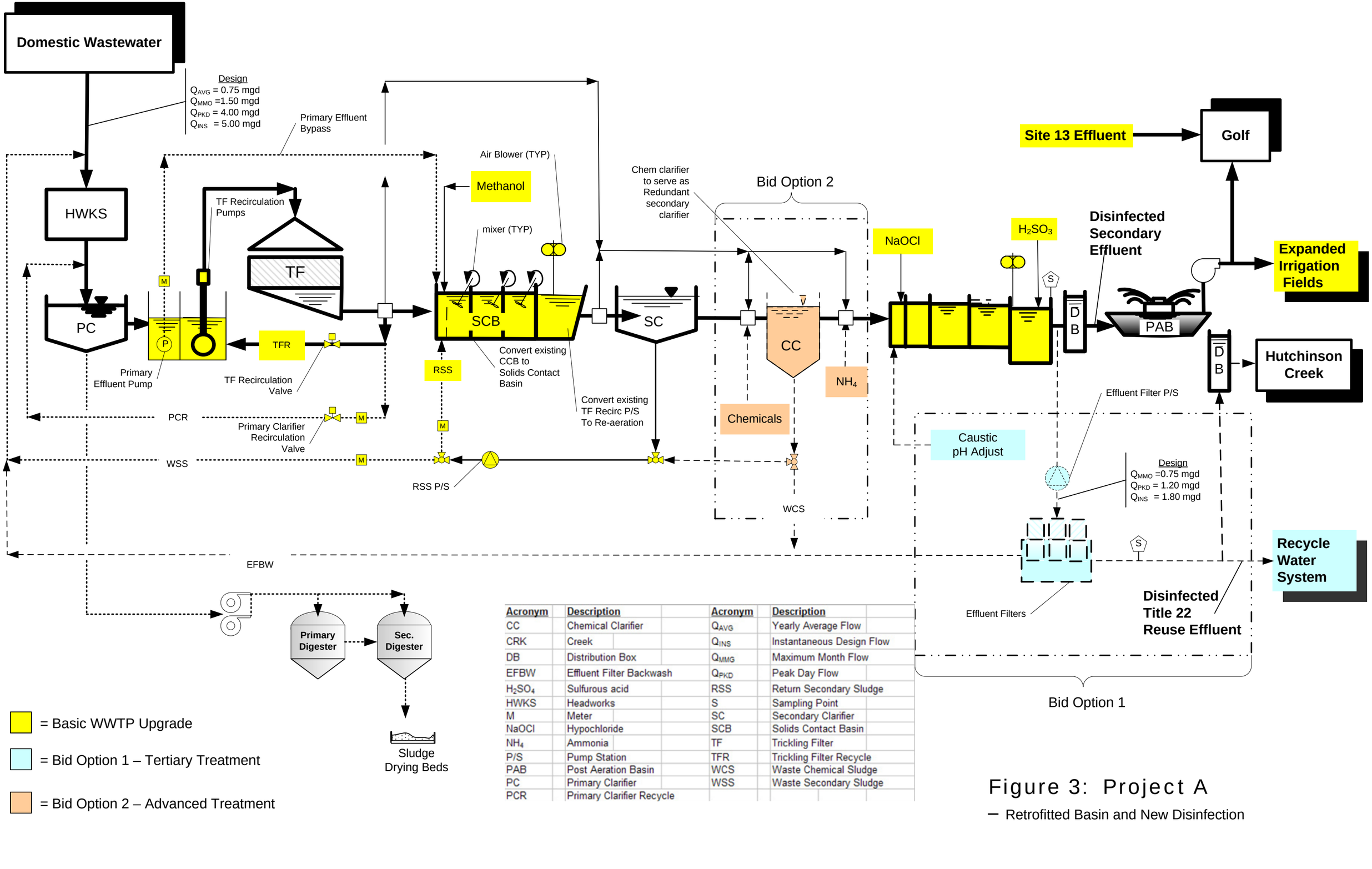


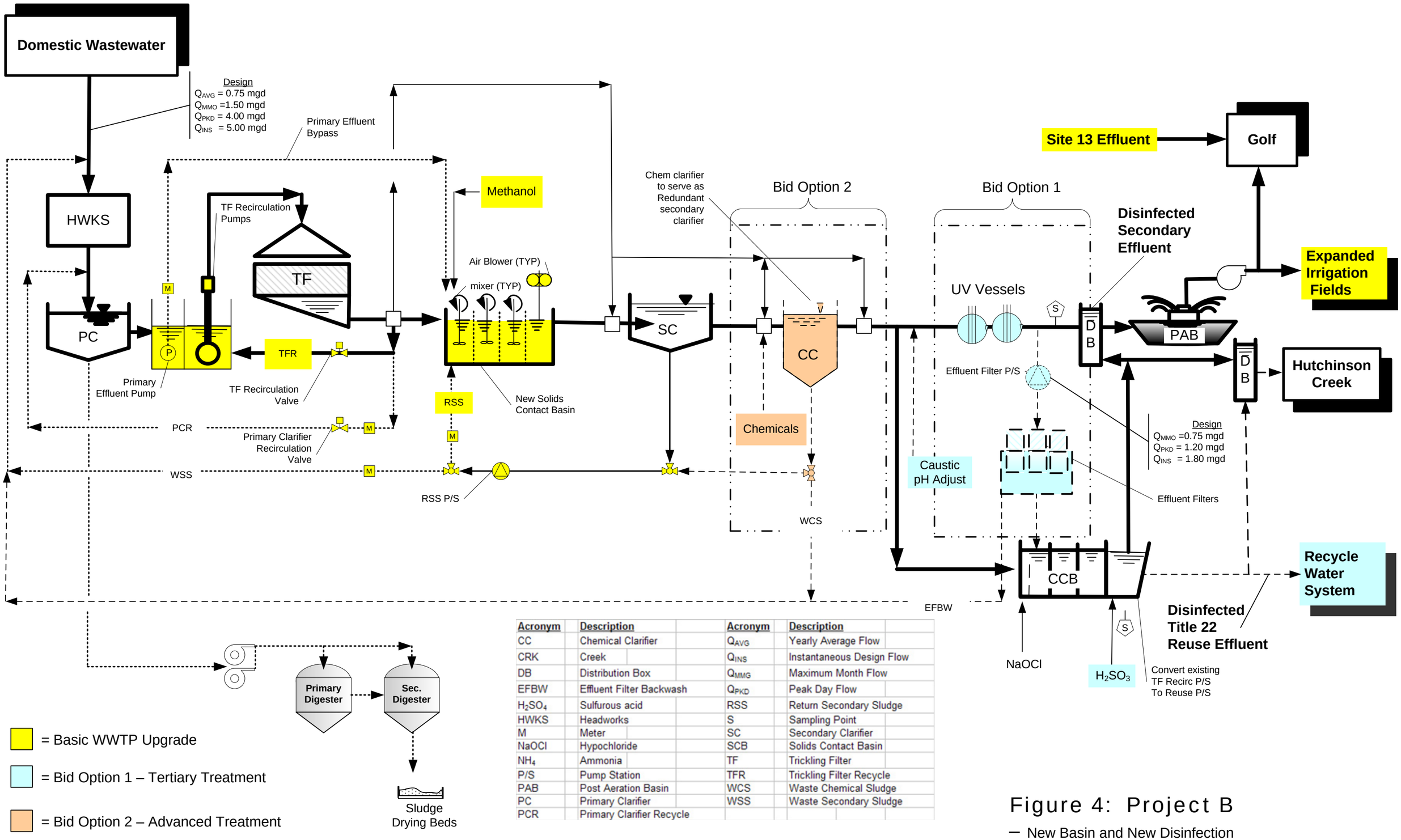

Figure 2: Flow Schematic – dN Filter Upgrade




| Acronym | Description | Acronym | Description |
|---|---|---|---|
| CC | Chemical Clarifier | $Q_{AVG}$ | Yearly Average Flow |
| CRK | Creek | $Q_{INS}$ | Instantaneous Design Flow |
| DB | Distribution Box | $Q_{MMG}$ | Maximum Month Flow |
| EFBW | Effluent Filter Backwash | $Q_{PKD}$ | Peak Day Flow |
| $H_2SO_4$ | Sulfurous acid | RSS | Return Secondary Sludge |
| HWKS | Headworks | S | Sampling Point |
| M | Meter | SC | Secondary Clarifier |
| NaOCl | Hypochloride | SCB | Solids Contact Basin |
| $NH_4$ | Ammonia | TF | Trickling Filter |
| P/S | Pump Station | TFR | Trickling Filter Recycle |
| PAB | Post Aeration Basin | WCS | Waste Chemical Sludge |
| PC | Primary Clarifier | WSS | Waste Secondary Sludge |
| PCR | Primary Clarifier Recycle | | |

Figure 3: Project A

– Retrofitted Basin and New Disinfection

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| CC | Chemical Clarifier | $Q_{AVG}$ | Yearly Average Flow |
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| PAB | Post Aeration Basin | WCS | Waste Chemical Sludge |
| PC | Primary Clarifier | WSS | Waste Secondary Sludge |
| PCR | Primary Clarifier Recycle | | |

Figure 4: Project B

– New Basin and New Disinfection