TETRA TECH

TECHNICAL MEMORANDUM

To: Christopher Cannon, Director, City of Los Angeles Harbor Department Environmental Management Division

CC: Ms. Shirin Sadrpour, Ms. Pauling Sun, and Mr. Chris Foley, City of Los Angeles Harbor Department Environmental Management Division

From: Ms. Cari Ferrell, P.E. and Ms. Heather Benfield, P.E., Tetra Tech

Date: January 12, 2016

Re: **Summary of Research Results on Discharge Water Treatment Options for New Dock Street Pump Station, Terminal Island, CA., ADP #940203-602, Agreement #14-3245; Time Schedule Order No. R4-2013-0109, Order No. R4-2013-0108, NPDES Permit No. CA0064157**

A. Introduction

A desk study and limited field studies were conducted to explore options to treat the stormwater and groundwater prior to discharge from the New Dock Pump Station ("Pump Station"). The options studied include: best management practices (BMPs) and various water treatment technologies. A summary of the options evaluated and their respective advantages, disadvantages, and their applicability to the Pump Station is provided in Table 1 below. Detailed descriptions of the technology assessment are provided in later sections.

B. Summary of Findings and Recommendations

The following summary tables presents the findings/recommendations of the stormwater BMP and treatment study.

Table 1. Comparison of Best Management Practices and Their Applicability to the Pump Station

Best Management Practices	Technology	Advantages	Disadvantages	Applicability
Bioretention	Traditional bioswale	Built into landscaping, low capital cost, dissolved metals removal	Large space needed, large volume infiltration limited if groundwater is shallow, periodic replacement, metals removal not expected to meet limits	Built into landscaping
	Self-contained filtration unit	Self-contained unit, low profile, low capital cost, dissolved metals removal	Limited applicability (curb inlets only), metals removal not expected to meet limits, may cause increase in fecal coliform	Installed at curb storm drain inlets

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Best Management Practices	Technology	Advantages	Disadvantages	Applicability
Sandbags Filled with Adsorbent	Zeolite, Metsorb™, oyster shells, MetalZorb®, fine bone meal, and Raynfilter®	Low cost, some materials readily available (zeolite), potentially sustainable options (e.g. oyster shells from local fish market)	Regular maintenance, metals removal not expected to meet limits, bacteria may increase from oyster shells	Place in filter bag at storm drain inlets or in drop inserts
Stormbasin / Stormpod	Cartridge filtration	Low cost, low profile	Poor bench scale test results for stormwater at local, confidential site	Filters in specialized storm drain inlet drop inerts

Table 2. Comparison of Water Treatment Technologies and Their Feasibility to the Pump Station

Treatment Technologies	Principles	Advantages	Disadvantages	Feasibility
StormwateRx®	Media filtration, ion exchange, and UV	Design for large range of flow rates, media remain effective with wet-dry cycles, built-in pre-treatment filtration, proven effectiveness of removing metals at low influent concentrations, and lease option available	Decreased effectiveness from salt content in influent water, high capital costs, requires regular monitoring and maintenance, and space required for larger systems including space for water storage to collect large storm events until water can be treated	Feasible for treating groundwater flow; space-limiting for treating stormwater runoff
AquaShield™	Sand and specialty media filtration	Rental available, small footprint, and potential bacteria destruction	Monthly monitoring and maintenance, uncertainty of effectiveness in wet-dry cycles and with salinity, and poor pilot study performance	Not feasible due to poor pilot study performance
Pure Effect system	Polymer coagulation, sand and carbon filtration	Compact design, rental available, effective removing total and dissolved metals, local readily available support, proven effectiveness in treating brackish water in nearby areas including previous construction sites at the Port, and capability to daisy-chain	Monthly operation and maintenance costs, capital costs, excess polymer removal with carbon, and space required for large water storage	Feasible for treating groundwater flow; space-limiting for treating stormwater runoff

Treatment Technologies	Principles	Advantages	Disadvantages	Feasibility
		systems to treat higher flows		
Chemical coagulation	Coagulation and filtration or sedimentation	Effective removal of particulate-bound constituents to meet discharge limits	Need for additional system components such as polymer removal, required storage volume, high capital costs, routine monitoring and maintenance costs, and potential problems from improper dosing	Feasible but more difficult /costly to implement than a filtration unit
Contech Filters	Clarifiers and cartridge filters	Underground installation, easy maintenance	Not capable of meeting low discharge limits	Not feasible for removing low levels of metals
Chitosan Enhanced Sand Filtration	Enhanced sand filtration	Potentially sustainable solution and potential for metals removal.	Uncertainty of the reliability (uncommon treatment method) and limited availability and vendors	Not feasible at this time (vendors primarily on east coast)
Jellyfish® filter	Membrane filter	Compact size, easy maintenance, high flow rate, and low driving head required	Initial high capital cost and lack of available data to demonstrate the ability to remove dissolved metals and bacteria	Not feasible based on unproven ability to remove dissolved metals and bacteria
Up-flo® filter	Fluidized bed media filter	Small footprint, high flow rate, soluble metals removal, and low maintenance	Salinity interference and potential problems installing at the depth of the Pump Station storm drains	Not feasible based on bench-scale testing by vendor (due to salinity interference)
Reverse osmosis	Reverse osmosis	Able to reliably achieve very low metals concentrations	High capital and operation costs and required pretreatment	Not feasible based on need for extensive pretreatment
Electrocoagulation	Electrically-stimulated coagulation	Effective treatment of dissolved and particulate pollutants without added chemicals, limited operator time with automation, and can be used for both stormwater and groundwater	High electrical usage and limited flow capacity for stormwater	Potentially feasible – would require research and pilot testing

Notes:
UV = ultraviolet

C. Detailed Evaluation

1. Best Management Practices (BMPs)

The BMPs are practices that could be implemented to the entire Pump Station storm drain network. Three BMPs were evaluated including:

- Bioretention
- Sandbags filled with zeolite or other filtration media
- Fabco Stormbasin/Stormpod

<u>1.1 - Bioretention</u>

Bioretention uses vegetation to filter and uptake metals in stormwater. When land is available, a bioswale can be built to allow metal uptake by the vegetation and water infiltration to groundwater or an underdrain that discharges to a receiving water body or pump station. Newer technologies have been developed to allow installations of bioretention treatment system in the curb-type stormdrain inlets with specially engineered filter media installed (e.g. Filterra®) to treat stormwater. Bioretention may remove metals (total and dissolved), total suspended solid (TSS), nutrients (e.g. phosphorous and nitrogen), and oil and grease (including hydrocarbons). Figures 1 through 4 show examples of bioswale and bioretention treatment systems.

Figure 1. Bioretention Swale

Figure 2. Bioretention Swale Cross Section

Figure 3. Standard Filterra® System with Curb Inlet Cross Section

Figure 4. Standard Filterra® System with Curb Inlet

Advantages of bioretention using traditional bioswales include that bioswales can be built into the landscaping and are relatively inexpensive to install. Disadvantages include the amount of space required for adequate retention times to achieve adequate treatment and prevent flooding and the need to remove and replace the bioswale when the soil and/or underdrain becomes clogged. In addition, bioswales attract birds which can lead to an increase in fecal coliform.

Advantages of bioretention using a filtration system such as Filterra® include that the system is self-contained in the curb stormdrains inlets, the unit is pre-assembled, easy access for maintenance (accessible from the surface), small and shallow footprint, and high flow volumes. Disadvantages include the primary use in curb drains rather than center drains which are more prevalent at the Pump Station and the Filterra system will not achieve expected pollutant removal efficiency according to their published efficiencies of >58% removal for total copper and 46% removal for dissolved copper.

1.2 - Sandbags filled with various filtration media

1.2.1 – Sandbags filled with Zeolite

Zeolite is an adsorbent typically used for copper and other metals removal from stormwater runoff. Sandbags filled with zeolite were evaluated for use in the surrounding of the circular storm drain inlets to remove metals. The majority of the zeolite manufacturers produce clinoptilolite zeolite and a local manufacturer produces laumontite (calcium feldspar) zeolite.

Figure 5. KMI Zeolite (4x8 size) - currently utilized at the New Dock Pump Station

Clinoptilolite type zeolite was obtained from multiple manufacturers including Bear River Zeolite Co., Inc., St. Cloud Zeolite, KMI Zeolite, Inc., and Ida Ore Mining, LLC, for field testing of the metal removal rates. Figure 5 shows KMI zeolite, which is currently used at New Dock at select storm drain inlets. Field testing of different types of zeolite was completed in December 2015. In addition, five sandbags were tested separately in November 2015 and some bags showed leaching of metals including copper and zinc. Based on the results, treatment by filtration with zeolite does not have the required copper removal efficiency to meet discharge standard, but it could serve as a necessary first step in the treatment process.

1.2.2 - Sandbags filled with other filtration media

Sandbags filled with other types of filtration media were evaluated for use in around selected storm drain inlets. They include Metsorb™, oyster shells, MetalZorb®, fine bone meal, and Raynfilter® a peat-based sorbent. Each adsorbent medium is described as follows:

- Metsorb™ media has claims to be able to treat water to meet drinking water standards and fast kinetics that permits shorter contact times. However, it is anticipated that severe backup or flooding of stormwater runoff at the storm drain inlets could occur due to extremely fine media size as shown in Figure 6. As a result, no further testing of Metsorb™ was conducted and using Metsorb™ in around a storm drain inlet at the Site is not recommended at this time.

Figure 6. Metsorb™ Media

- Oyster shells have been used by the Port of Seattle in modified storm drain catch inserts for removing copper (dissolved) and increasing hardness (which reduces the bioavailibility of metals in water) (Figure 7). The oyster shells remove copper by absorption. The Port of Seattle reported a 70% of copper reduction (See a video prepared by the Port of the Seattle at: [http://www.portseattle.org/Environmental/Water-Wetlands-Wildlife/Stormwater/Pages/default.aspx)](http://www.portseattle.org/Environmental/Water-Wetlands-Wildlife/Stormwater/Pages/default.aspx). The maintenance consists of using a vacuum truck once a year to remove the spent oyster shells and then replace with fresh oyster shells in the catch basins. Local oyster shells are available at the Fish Market (Berth 72) and pilot

Figure 7. Oyster shells in a modified storm drain inlet at the Port of Seattle

tests will be conducted at the Pump Station. The Port of Seattle does not sample for bacteria, but it is a requirement for the Pump Station and will be evaluated in the pilot tests.

- MetalZorb® is a treated sponge product used for the removal of heavy metals (dissolved) through ion absorption and filtration (Figure 8). The sponges are designed to handle high flow rates without leaching. Advantages include the ease of installation, high flow rate, and long lifespan. Disadvantages include temperature and moisture dependence on effectiveness and the need for new or existing filtration vault for optimum performance (Figure 9). Preliminary bench-scale testing indicated metal leaching from the tested sample obtained from the manufacturer, which is contradictory to the manufacturer's claim. As a result, it is not recommended to implement this media as a BMP option at the Pump Station.

Figure 8. Metal Zorb®

Figure 9. MetalZorb® installed in a filtration vault

- Raynfilter® is a peat-based stormwater filtration medium (Figure 10). Literature shows that Raynfilter was only used in small-scale application in roof drain filters. It may not be capable of meeting the required metal removal efficiency. Furthermore, its impacts on bacteria and toxicity are unknown. As a result, the Raynfilter® is not recommended as a BMP for the Site for the time being.

Figure 10. Raynfilter® media

1.3 Fabco Stormbasin/Stormpod

The Fabco Stormbasin and Stormpod are storm drain inlet basins that are installed in circular and curb storm drain inlets and use a selected cartridge filter depending on the target pollutants (Figure 11 and Figure 12). The system has a bypass to prevent previously collected trash and sediment from being washed out in extreme storm events. Filter cartridges are available for hydrocarbons and metals. Bench testing at another confidential site demonstrated poor performance in treating metals – in general, concentrations of metals were unchanged or demonstrated an increase. Therefore, it is not expected to be able to meet the treatment challenges at the New Dock Pump Station.

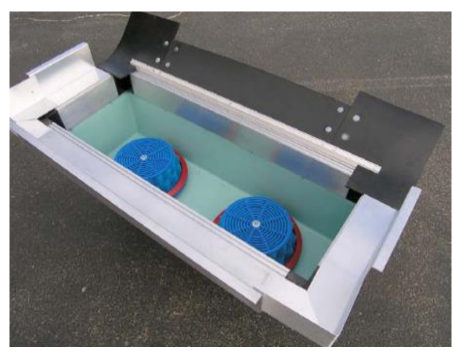

Figure 11. Fabco StormBasin

Figure 12. Fabco StormPod

2. Water Treatment Methods

There are numerous methods that could be used for off-line treatment, but all would require modifications to the Pump Station infrastructure and installation of a treatment compound. The treatment methods reviewed include the following:

- StormwateRx®
- AquaShield™
- Pure Effect system
- Chemical coagulation
- Contech Filters
- Chitosan Enhance Sand Filtration
- Jellyfish® filter
- Up-flo® filter
- Reverse osmosis
- Electrocoagulation

2,1 StormwateRx®

StormwateRx® carries multiple types of stormwater treatment technologies including the Aquip® and the Purus® filters (Figure 13 and Figure 14). Aquip® disperses stormwater over a bed of a patented media filter and removes fine particulates and dissolved pollutants. Purus® is a type of ion exchange filter that removes fine particulates, dissolved metals (in parts per billion, ppb, range), VOCs, PCBs, PAHs, and bacteria. A UV lamp can be installed at the end of the process to destroy bacteria. StormwateRx® provides a one-year warranty for their system.

Advantages of Aquip® include the ability to handle any flow rate (ranged from 5 to 600 gallon per minute or gpm typically), media remain effective even going through wet-dry cycles, built-in pre-treatment filtration, and effectiveness of removing metals. Disadvantages include decreased effectiveness from salt content in influent water, high capital costs, required monitoring to prevent breakthrough when media is spent, regular maintenance (long term maintenance cost cannot be determined until system runs for a period of time; initially it will require weekly monitoring), and space required for larger systems capable of treating all stormwater runoff including space for water storage required to provide constant flow rate to filter.

Figure 13. Aquip® Treatment Unit

Figure 14. Aquip® Pilot Test Unit

The Purus® system is designed to follow treatment by an Aquip® unit (Figure 15 and Figure 16). Advantages of the Purus® system include high quality effluent and a compact design. Disadvantages include decreased effectiveness from salt interference, high capital cost, and required regular maintenance.

Figure 15. Purus® Treatment Unit

Figure 16. Purus® Pilot Test Unit

A pilot study was conducted to test the performance of the Aquip® and Purus® filters with a UV lamp at the Pump Station. The preliminary results showed promise of good metals removal using the Aquip® (66-95% removal of copper), but influent metals concentrations were relatively low. Higher concentrations in the influent water may not be removed to the required concentrations. The Purus® system is intended to remove metals not removed by the Aquip®, but the pilot testing did not demonstrate additional removal by Purus® due to the relatively low influent concentrations. As a result, additional testing of Aquip® and Purus® units to determine their effectiveness treating high concentrations of metals in the influent is recommended due to the potential for salt inference with the ion exchange media used in the Purus® system. Additionally, a UV system can be installed after the Purus® system to treat bacteria. However, the impact by possible iron fouling to the UV lamp is unknown, but the additional maintenance may be worthwhile because of the consistently effective bacteria removal (90-99% removal of enterococcus and total/fecal coliform in pilot testing). Additional pilot testing is recommended to determine the performance of the Aquip® and Purus® system at higher concentrations of copper.

2.2 AquaShield™

AquaShield™ is a cross-flow sand filter typically used to reduce turbidity in construction site runoff (Figure 17). AquaShield™ uses PathShield™, a proprietary media that is used to physically remove bacteria from the treated water. The AquaShield™ GoFilter system can remove solids to 0.5 microns in size. AquaShield™ carries rental units as well as permanent installations of variable sizes. Advantages of the AquaShield™ GoFilter is the ability to rent a unit as needed such as for wet weather season, has a small footprint, and the PathShield™ media provides bacteria destruction. Disadvantages include the monthly maintenance required and the uncertainty of effectiveness in wet-dry cycles and with salinity.

Figure 17. AquaShield™ Demo Unit

A bench scale field test was conducted using a column of PathShield™ media and showed good removal of bacteria (>81% removal for total coliform and 61% removal of enterococcus). A pilot test was then conducted using a GoFilter demonstration unit that is comprised of sand and the PathShield™ media. The results of the pilot study showed poor and/or inconsistent removal of metals (5-38% removal or increase of copper) and bacteria (38-99% removal or increase/no change of enterococcus and 85-99% removal or no removal/increase of total coliform). This could be caused by the unique site conditions including the brackish water and the intermittent operation of the system. Therefore, the AquaShield™ system is not recommended for the Pump Station.

2.3 Pure Effect System

Pure Effect carries various types of groundwater and stormwater treatment systems. In general, a treatment system consists of holding tanks, pumps, bag filters, chemical/polymer injection, filtration vessels, and related meters, ports, connections, and gauges (Figure 18). Pure Effect recommended a process including a polymer injection, bag filters, activated carbon filtration, and media filtration for the Pump Station. Chemical/polymer injection is used to generate larger particles (e.g. coagulation/flocculation) that are filtered out in the subsequent media filtration vessel. The polymer used would be selected to remove the target pollutants including copper. Any excess polymer would be removed by carbon filtration to prevent downstream toxicity.

Figure 18. Pure Effect Demo Unit (10 gpm capacity)

The vessels have a 3-year warranty and their interior walls have thick liners to prevent corrosion and rust from brackish water. Pure Effect provides treatment systems for purchase or rental. The advantages include the the compact design, option for rental of system, the ability of treating both groundwater and stormwater to the required effluent standards, local readily available support, and the proven effectiveness in treating brackish water in nearby areas including previous construction sites at the Port. Systems up to 500 gpm in capacity can be daisy-chained to treat higher flows for stormwater treatment. The disadvantages include monthly operation and maintenance costs, high capital costs (low compared to other similar treatment systems), the dosing of the polymer and related concerns (e.g., excess polymer removal with carbon, toxicity, etc.), and space required for larger systems capable of treating all stormwater runoff including water storage required to provide aconstant flow rate to the system. It is recommended that pilot testing be conducted with high metal concentrations in the influent water to determine the effectiveness of the system at the Pump Station to compare to other options.

2.4 Chemical Coagulation

Chemical coagulation is a treatment method that adds a chemical to facilitate the generation of larger flocs or groupings of smaller particles for more efficient removal by sedimentation. Different chemicals can be used depending on the specific water chemistry, but incorrect dosing can cause problems such as toxicity. Effective chemical coagulation requires close monitoring of the chemical dosing and concentrations of constituents.

Advantages of chemical coagulation include effective removal of particulate-bound constituents. Disadvantages include the required storage volume, high capital costs, constant monitoring and maintenance, potential problems from improper dosing, and operations and maintenance costs. Chemical coagulation can be used as part of a stand-alone unit, such as the aforementioned Pure Effect system, as an option for water treatment at the Site because the infrastructure changes to the existing Pump Station would be minimized and removal of excess coagulant can be incorporated as part of the treatment process. It is recommended that coagulation only be further researched and/or tested as a pre-fabricated unit such as the Pure Effect system since many of the disadvantages of the treatment method are addressed and minimized in the design of a pre-fabricated, stand-alone unit with filtration and excess polymer/coagulant removal.

2.5 ConTech Filters

ConTech provides treatment of stormwater by using underground vaults with clarifiers and/or cartridge filters (Figure 19). The StormFilter® targets solids, heavy metals, oil and grease, and nutrients. However, ConTech representatives indicated that the system carried by ConTech would not be capable of reaching the low copper concentrations required for the Pump Station. Therefore, it is not recommended for the Pump Station.

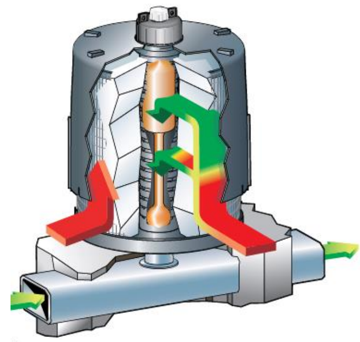

Figure 19. ConTech StormFilter® Cross Section

2.6 Chitosan Enhanced Sand Filtration

Chitosan enhanced sand filtration uses chitosan produced from crab shells and other crustaceans to increase the size of the particles (e.g. the "floc") in the stormwater and/or groundwater prior to sand filtration. The chitosan binds negatively charged molecules including total suspended solids (TSS), hydrocarbons, metals (total and dissolved), and organics. Chitosan is typically used for treating construction site stormwater runoff and is capable of handling a wide range of flow rates. Chitosan has a low potential for toxicity, but there is a lack of support research results to demonstrate safety levels of chitosan for aquatic species in a receiving water body. Advantages include it's a sustainable solution (reuse of crab shells) and potential for metals removal. Disadvantages include the uncertainty of the reliability of the treatment since it's not a common method and limited availability and vendors. It is not recommended for the Pump Station unless testing with a local source demonstrates effective metal removal.

2.7 Jellyfish® Filter

The Jellyfish® Filter is a membrane filter that can be installed in a manhole along a stormdrain line or in an off-line configuration (Figure 20). The membrane filter comes with a compact pretreatment that can remove TSS, nutrients, total metals, turbidity, and trash.

Advantages of the Jellyfish® Filter include its compact size, easy maintenance and low life cycle cost, high flow rate, low driving head required, and backwash capability using filtered water after peak storm event to keep the membrane clean. Disadvantages include the initial high capital cost and lack of available data to demonstrate the ability to remove dissolved metals and bacteria. Therefore, it is not recommended for the Pump Station at this time.

Figure 20. Jellyfish® Filter Manhole Cross Section

2.8 Up-flo® Filter

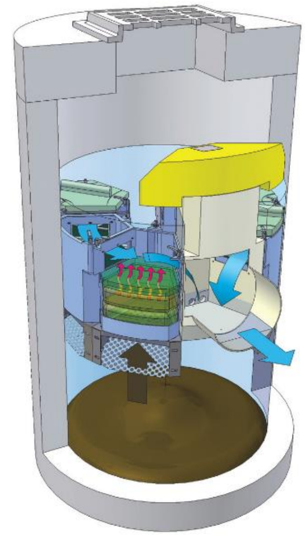

Figure 21. Up-Flo® Filter Cross Section

Hydro International's Up-flo® Filter can be installed below-grade in an on- or off-line application (Figure 21). The Up-flo® Filter is a fluidized media filter that directs water flow upward through the filter media. An engineered filter media mix can be designed to include removal of metals and other constituents. Although the system can remove soluble metals, salinity interference with the effectiveness of the media is a concern. A standard 4-foot manhole system can treat up to 150 gpm and typically has an 18-month maintenance cycle using a vacuum truck to remove spent media.

Advantages of the Up-flo® Filter include the small footprint, high flow rate, soluble metals removal, and low maintenance. Disadvantages include the salinity interference and potenial problems installing at the depth of the Pump Station storm drains.

Water samples collected from the Pump Station were sent to Hydro International for a bench-scale testing using Up-flo® Filter. The results showed that the salinity interference has a significant impact on the system's effectiveness. Therefore, the Up-flo® filter is not recommended for the Pump Station.

2.9 Reverse Osmosis

Reverse osmosis is a treatment process using membranes to remove dissolved contaminants including salts, pharmaceuticals, and dissolved metals. Membranes are capable of filtering very small size particles. A reverse osmosis system uses a large amount of power and requires pretreatment to remove large particulates to prevent clogging in the membranes. The advantages include the ability to achieve very low metals concentrations. Disadvantages include the high capital and operation costs and the space and costs associated with pretreatment to remove larger sized contaminants. It is not recommended for the Pump Station at this time due to the high capital costs and required pretreatment.

2.10 Electrocoagulation

Electrocoagulation is a newer water treatment process that applies a charge to the water to generate flocculation. The flocculation is followed by a sedimentation or filtration process. The advantages include effective treatment of dissolved and particulate pollutants without added chemicals, limited operator time with automation, and can be used for both stormwater and groundwater. Disadvantages include high electrical usage and limited flow capacity for stormwater. It is not recommended for the Pump Station at this time, but further research may be recommended depending on the results of pilot testing of other systems.

D. Recommendations

Based on the variety of options researched, Tetra Tech recommends multiple methods to address elevated levels of metals in discharges from the New Dock Pump Station.

First, source control should continue to be pursued in the long term to minimize concentrations of contaminants that enter the groundwater and stormwater collected at the New Dock Pump Station. Some of the sources may include aerial deposition, shedding of vehicle brake lining, and wear of vehicles tires. Tetra Tech recommends the continued use of BMPs including regular vacuum-assisted street sweeping, stormdrain pipeline maintenance and leak repair, the use of zeolite-filled sand bags around select stormdrain inlets, and the use of drop inserts in the at-grade and curb-type stormdrain inlets to collect large particles and trash.

Due to the low concentration discharge limits required by the NPDES permit, additional water treatment is recommended to prevent exceedances in the discharge. Tetra Tech recommends additional pilot testing of the

StormwateRx® system as well as pilot testing of the Pure Effect system to determine which system should be purchased and installed or rented. The two systems show the most potential to achieve the low concentrations of metals required with the challenges at New Dock Pump Station.

For stormwater, however, a much larger system or series of systems would be required to treat the storm runoff volume possible. At this time, Tetra Tech recommends that the treatment of the groundwater be addressed first. A better design for a stormwater system to run in series could then be developed based on the performance of the groundwater treatment system. The treatable flow for a stormwater system would be limited by available space.