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DRAFT Memorandum

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From: *Greg Wetterau, CDM*

Date: *April 1, 2011*

Subject: *Santa Ana Regional Interceptor (SARI) Solids Control Alternatives Conceptual Costs*

This memorandum evaluates three alternatives for addressing suspended solids generation within the SARI pipeline, including: 1) Continuing with the current practice of allocating the solids imbalance to hardness and BOD dischargers, while periodically cleaning solids deposits from the SARI, 2) injecting ethylenediamine tetra acetic acid (EDTA) to control formation of suspended solids, and 3) converting all or a portion of the gravity SARI line into a pressure line. The costs of these alternatives are compared to determine the impacts of each potential approach.

1.0 Background

The Santa Ana Watershed Project Authority (SAWPA) owns and operates the SARI line within San Bernardino and Riverside Counties, accepting brine and other wastewater discharges within the Santa Ana Watershed. This interceptor was initially constructed to provide disposal of highly saline discharges from groundwater desalination facilities, power plants, and industrial users, in order to protect the inland water quality in the upper Santa Ana River Watershed. Due to the initially low flows of these higher salinity wastewaters, the SARI line has temporarily accommodated lower salinity domestic and industrial wastewaters to provide revenue and maintain system flows closer to design capacities.

The SARI pipeline conveys the wastewater to the Orange County Sanitation District (OCSD) system, where the water is treated and ultimately discharged through an ocean outfall. OCSD charges SAWPA for treatment and disposal, based on the flow, biochemical oxygen demand (BOD), and TSS of the wastewater measured at the Orange County Meter (S01). SAWPA then charges agencies discharging to the SARI line based on the same parameters, with predetermined rates established to cover the charges from OCSD, pipeline maintenance, and other related costs to SAWPA.

Large differences between measured levels of TSS entering the SARI line and those measured at the Orange County line (S01) have been observed over the last several years, with the TSS often measuring twice as high at the S01 meter, compared to the TSS entering the system. These differences created two problems:

1. Solids deposition in the pipeline that require expensive annual cleaning

2. Revenue imbalance, where the expenses for TSS fees from OCSD could not be offset by revenue received without allocating the costs to dischargers of non-suspended solids (Biochemical oxygen demand, BOD, and hardness).

SAWPA initiated the SARI Sediments and Solids Control Study to identify means of controlling organic and inorganic solids generation in the SARI line. Previous studies have determined that suspended solids are formed through the precipitation of hardness (calcium) from desalination brine and from the coagulation of dissolved organic compounds when waters with high levels of total organic carbon (TOC) are blended with high hardness desalination brine.

A bench study conducted by CDM in 2010 indicated that the addition of 50 mg/L EDTA can significantly reduce the formation of both organic and inorganic suspended solids in samples taken from the SARI line. The EDTA did not add any BOD or TSS to the water and is a non-hazardous organic compound that is not limited by current or anticipated wastewater regulations. It was therefore suggested that EDTA injection at various points along the SARI line could be used to control both scale formation and reduce the suspended solids imbalance.

Previous bench testing also indicated that contact with air is a major contributor to scale formation. This is evident with the scale build-up at all of the desalter air gaps, but was also measured during 2009 SARI line bench testing where desalination brine samples left in sealed, head-space free containers did not exhibit the inorganic solids formation seen in the open containers. It has been observed with pressurized brine lines operated in Texas and Florida that scale formation can be prevented by maintaining full pipe flows with no air-to-water contact. A 27 mile pipeline in El Paso, Texas has been in operation for 4 years with similar water quality to the SARI line and no reported formation of scale. One alternative for preventing inorganic scale formation could be the pressurization of the SARI line, however, this alternative should not be expected to have an impact on the formation of organic suspended solids.

This memo develops conceptual costs for injecting EDTA and converting all or a portion of the existing gravity line to a pressure line. The costs for these alternatives are compared with the current approach, which includes cleaning the SARI line and paying for the solids imbalance.

2.0 Solids Control Alternatives

Existing solids control measures include periodic pipeline cleaning and allocating costs for unaccounted for OCSD TSS fees to dischargers with measured quantities of biochemical oxygen demand (BOD) and total hardness (calcium and magnesium). TSS imbalance charges are divided evenly between BOD and total hardness using the following formula:

$$TSS_b = TSS_m + 0.5*TSS_i*BOD_m/BOD_t + 0.5*TSS_i*TH_m/TH_t$$

Where:

TSS_b = billed TSS to user
TSS_m = measured TSS for user
TSS_i = TSS imbalance, or TSS at OCSD meter minus total TSS measured for all users
BOD_m = measured BOD for user
BOD_t = total measured BOD for all users
TH_m = measured total hardness for user
TH_t = total measured total hardness for all users

BOD is also the basis for a separate solids fee from OCSD, however, it was selected for use in the TSS imbalance formula, since it is believed that the dissolved organic matter characterized by the BOD measurement is directly related to the formation of volatile suspended solids (VSS) through coagulation and through biological growth. Total hardness was selected for use in the TSS imbalance formula as the divalent hardness ions have been found to promote the coagulation of organic matter, while also forming scale on the SARI line walls.

Solids formation in the SARI line has increased substantially over the last two years. A significant reduction in solids formation was seen in 2009 after a major cleaning program on several SARI line reaches. Solids formation began to increase again in late 2009 and 2010, with TSS loading at the OCSD meter currently twice the TSS entering the system from the upstream dischargers (approximately 250 mg/L of TSS formation). At the same time, scale formation has become a costly challenge, requiring extensive cleaning for large segments of the SARI line and contributing laterals. Annual cleaning costs over the past five years have averaged $380,000, with $376,000 per year budgeted for the current and upcoming fiscal years.

To evaluate the cost of control alternatives, the following assumptions were made:

<u>Alternative 1 - Baseline Alternative</u>

- The baseline alternative assumes current practices will be maintained, cleaning the pipelines as needed and paying the fees for solids imbalance.

- While it is not clear what the long term cleaning frequency and required cleaning measures will be, it was assumed for analysis purposes that 25 percent of the upper SARI line will require cleaning every year and that all siphons will be cleaned on a quarterly basis. The total pipe length in all upper SARI reaches is 73 miles with the total length of siphons 2,434 feet.

- An average TSS imbalance of 250 mg/L was assumed, which would continue relatively unchanged. Current flow in the SARI line is 12 mgd, and it was assumed that this would increase 7 percent per year until the maximum flow of 30 mgd is reached.

Alternative 2 – Addition of EDTA

- This alternative assumes injecting EDTA at 50 mg/L, injected at all desalination facilities discharging to the SARI line. This assumes five EDTA injection points.
- The average flow for EDTA injection is currently 12 mgd, but is assumed to increase 7 percent per year until the maximum flow of 30 mgd is reached.
- It is assumed that cleaning costs will be decreased to 25 percent of the cleaning costs required under the baseline alternative (75 percent reduction).
- It is assumed that the TSS imbalance will be reduced by 60 percent compared with the baseline alternative.

Alternative 3 – Conversion to Pressurized Pipeline

- On reaches IV, IVA, IVB, IVD, and IVE, there are a total of 363 manholes which would need to be converted to pressure manholes.
- The existing pipe can take up to 100 feet of pressure; flow regulating valves (manual) will be installed at 40 to 60 feet elevation intervals along the reaches. The flow regulating valves would be installed in the existing manholes.
- Reach V contains two pressure rated manholes which would not require modifications.
- Reach V pipe can hold pressure to 200 ft and flow control valves will be installed every 150 feet of elevation differential.
- Air gaps at discharges would be eliminated with check valves and hard piped connections installed in their place.
- It is assumed that cleaning costs will be decreased to 25 percent of the cleaning costs required under the baseline alternative (75 percent reduction).
- It is assumed that the TSS imbalance will be reduced by 20 percent compared with the baseline alternative, representing a reduction in inorganic TSS formation, but no reduction in organic TSS formation.

Profiles of the SARI pipeline reaches are summarized in Table 1.

Table 1 – Summary Profile for SARI Pipeline

	Existing Manholes (number)	Pipe Length (ft)	Elevation Differential (ft)	Proposed Flow Control Valves (number)
Reach IV	18	17,400	28	1
Reach IVA	72	41,800	157	3
Reach IVB	98	55,800	260	4
Reach IVD	150	113,800	376	7
Reach IVE	25	37,100	140	2
Reach V	2	120,800	880	5
Total	**365**	**386,700**		**30**

3.0 Cost of Alternatives

Conceptual level costs, including initial capital and annual operations and maintenance (O&M) costs, were developed for the three solids control alternatives presented above. All capital costs include a 40 percent construction contingency, 10 percent general conditions, and 25 percent engineering, construction management, and legal costs. Other assumptions used in development of these costs are listed below.

<u>Alternative 1 - Baseline Alternative</u>

The baseline alternative has no capital cost.

The O&M cost for the baseline alternative includes pipeline cleaning costs and increased fees due to the projected solids imbalance.

- Initial cleaning cost for the pipeline is assumed to be $2 per linear foot for the majority of the pipeline with cleaning of the siphons assumed to cost $6 per linear foot.

- An average 25 percent of the SARI line will require cleaning every year, with all siphons cleaned quarterly. This cleaning rate is assumed to remain constant over the 20 year planning period.

- Debris hauling was estimated at $50,000 per year and inspection, including sonar, at $35,000 per year, based on current costs.

- Cleaning costs are assumed to increase 5 percent per year, based on increasing labor rates.

- Costs for the solids imbalance are based on the following assumptions:

  - Average TSS imbalance is 250 mg/L throughout the planning period

    - An OCSD Charge for TSS of $312 per thousand pounds will remain throughout the planning period
    - A current average flow of 12 mgd will increase 7 percent annually until the full capacity of 30 mgd is reached

- Present value projections of annual costs assume a 6 percent discount rate over 20 years

<u>Alternative 2 – Addition of EDTA</u>

Alternative 2 assumes that EDTA storage and feed systems will be installed at five locations along the SARI line. Chemical feed systems will include dry feed facilities, mix tanks, and injection systems sized for the ultimate capacity at build-out (30 mgd SARI line flow). The following assumptions were used to develop initial capital costs:

- Dry feeder bins holding 20 to 60 tons will be required for 30-day supply at build-out
- Variable speed auger feed systems will be used without redundancy, dosing into batch tanks
- The average costs for EDTA storage and feed system are estimated at $287,000 for each of five facilities, including all contingencies, markups, and implementation costs.

The O&M costs for Alternative 2 include the cost of EDTA purchase, remaining pipeline cleaning costs, and remaining increased fees due to the solids imbalance. The following assumptions were made to develop O&M costs:

- EDTA chemical costs
    - Unit price $0.90 per pound, delivered
    - Average dose 50 mg/L
    - Initial SARI flow 12 mgd, increasing 7 percent annually until reaching build-out at 30 mgd
- Pipeline cleaning costs were assumed to be 25 percent of those anticipated for Alternative 1
- Costs for the solids imbalance were assumed to be 40 percent of those anticipated for Alternative 1
- Present value projections of annual costs assume a 6 percent discount rate over 20 years

<u>Alternative 3 – Conversion to Pressurized Pipeline</u>

Alternative 3 assumes that the entire upper SARI line would be converted to a pressure system, with discharge air gaps removed and converted to hard piped arrangements, flow control valves added, and manholes converted to pressurized manholes. Reach V is assumed to have a considerably lower cost to convert, since it was designed originally as a pressure pipeline and the two recently installed manholes are already rated for pressure conditions. The following additional assumptions were made in developing the capital cost for Alternative 3:

- The total cost for converting a single manhole into a pressure manhole is $280,000, including all contingencies, mark-ups, and implementation costs. A total of 363 manholes would require conversion.

- A total of 22 flow control valves would be installed at manholes to maintain acceptable pressures in all reaches. The average cost of each flow control valve is estimated to be $56,000, including all contingencies, mark-ups, and implementation costs.

- A total of 32 existing discharge points would need to be converted from open, air-gap discharges to closed pipes with check valves. It is assumed that these conversions can be made without pumping into the SARI line by minimizing pressures using flow control valves. The cost of each discharge conversion is estimated to be $28,000, including all contingencies, mark-ups, and implementation costs.

Similar to Alternative 2, it is assumed that the pipeline will still need to be cleaned at a reduced frequency compared with the baseline alternative. It is further assumed that the solids imbalance will be reduced by approximately 25 percent, representing a reduction in inorganic suspended solids formation without any anticipated reduction in organic coagulation or organic solids formation. The following assumptions were made to develop O&M costs:

- Pipeline cleaning costs were assumed to be 25 percent of those anticipated for Alternative 1

- Costs for the solids imbalance were assumed to be 80 percent of those anticipated for Alternative 1

- Present value projections of annual costs assume a 6 percent discount rate over 20 years

<u>Summary of Costs</u>

Projected capital and O&M costs for each alternative are presented in Table 2. The table also lists present value estimates of projected O&M costs with a net present value cost for each alternative.

Table 2 – Projected Costs for Solids Control Alternatives

	Alternative 1	Alternative 2	Alternative 3
Pipeline Cleaning (initial)	$338,000	$85,000	$85,000
Solids Imbalance (current flows)	$2,849,000	$1,140,000	$2,279,000
Cost of EDTA (current flows)	$0	$1,644,000	$0
Initial Annual O&M Cost	$3,187,000	$2,869,000	$2,364,000
Present Value of O&M Costs[1]	$61,353,000	$55,717,000	$45,877,000
Initial Capital Cost[2]	$0	$1,435,000	$104,231,000
Net Present Value	$61,353,000	$57,152,000	$150,108,000

1. *Based on 6% discount rate over 20 years with flows in SARI line increasing 7% per year until build-out and pipeline cleaning costs increasing 5% per year.*
2. *Includes 40% construction contingency, 10% general conditions, and 25% engineering construction management, and legal.*

4.0 Conclusions and Recommendations

Review of the projected costs for the three alternatives indicates that Alternative 3 will be considerably more costly than either continuing the current cleaning practices (Alternative 1) or using EDTA to reduce solids formation (Alternative 2). The primary cost involved with Alternative 3 is the conversion of 363 manholes into pressure manholes, which could cost more than $100 million, based on a burdened cost per manhole of $280,000 (including a 40 percent contingency). While it is expected that this alternative would prevent scaling of the system, it would be highly beneficial to convert a smaller portion of the SARI line to a pressure pipeline first, before considering the commitment of funding to pressurize the entire system. Converting Reach V, for instance, would be far less costly, requiring only the conversion of 3 discharges into hard-piped discharge points and the addition of five flow control valves. Such a conversion would be expected to have a large impact on scale formation in Reach V, and could be used as a pilot case before evaluating the benefits of converting larger portions of the SARI line.

The cost of feeding EDTA at a dose of 50 mg/L, while adding $1.6 million to the annual operating costs, is projected to be less costly than maintaining current cleaning practices, while continuing to pay for the suspended solids imbalance. Alternative 1 may, however, prove to be less costly than anticipated, as the TSS imbalance fees may result in dischargers reducing their hardness and BOD loads to the system, producing a positive benefit to long term operations. However, the projected cost savings associated with the use of EDTA, totaling more than $4 million in present value, warrant further investigation.

Previous bench testing results indicated that the use of EDTA could reduce TSS formation by more than 60 percent, while greatly reducing the risk of scale formation. Capital costs associated with implementing an EDTA feed system are relatively low, however, before committing the funding associated with the design and installation of permanent chemical feed equipment, it would be beneficial to conduct a full-scale demonstration study on a portion of the SARI line. It is recommended that Reach IV-E and IV-D be considered for a demonstration test to minimize the volume of flow while providing a mix of both high organic wastewater flows and high salinity desalination concentrate. A temporary EDTA feed facility would be installed at the Chino II Desalination Plant, with manual batching of EDTA suspensions maintained in a continuously mixed tank. The EDTA would be fed for a period of 4 days, with TSS and other water quality parameters measured before and during the injection period to evaluate full scale impact on TSS formation. If the control method proves to be effective in full-scale operation, it should be further evaluated for long term use in the SARI line. Other control methods which should also be investigated include the reduction of hardness loads in the discharges and the reduction of dissolved organic carbon (DOC) loads either through the rate structure or through direct water quality limits.