City of Riverside

WASTEWATER COLLECTION AND TREATMENT FACILITIES INTEGRATED MASTER PLAN

VOLUME 8: SOLIDS TREATMENT AND HANDLING
CHAPTER 4: SOLIDS PRODUCTION AND THICKENING OPTIONS

FINAL
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City of Riverside

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TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

SOLIDS PRODUCTION AND THICKENING OPTIONS

4.1 PURPOSE

The purpose of this chapter is to evaluate thickening alternatives for the City of Riverside (City) Regional Water Quality Control Plant (RWQCP) expansion. Alternatives for primary thickening, Waste Activated Sludge (WAS) thickening and co-thickening are included in the evaluation. The detailed layout and specific equipment type would be determined during the preliminary and final design.

4.2 RECOMMENDATIONS AND CONCLUSIONS

- Based on the Dissolved Air Flotation Thickeners (DAFTs) design criteria, the DAFTs are operating near their rated capacity, assuming no polymer addition.
- For ease of Operation and Maintenance (O&M), the same type of thickening equipment is recommended for both primary and secondary thickening facilities
- Based on solids projections and design criteria for Gravity Belt Thickeners (GBTs) and Rotary Drum Thickeners (RDTs), it is estimated that 14 units of either type of thickening equipment will be required.
- The City has chosen to provide separate thickening facilities for primary solids and WAS, using GBTs for both types of solids.

4.3 BACKGROUND

The RWQCP is a tertiary wastewater treatment plant that currently treats approximately 33 mgd. Existing thickening processes include in-tank thickening for the primary sludge, and DAFTs for thickening of WAS.

The following list of solids handling alternatives to be considered for this master plan was determined during the Kick-off meeting in July 2006:

1. Primary Thickening:
    a. Gravity Thickeners.
    b. GBTs.
    c. RDTs.
    d. Co-thickening with GBTs and RDTs.
2. WAS Thickening:
    a. Centrifuge.
    b. GBTs.

c. RDTs.
d. Co-thickening with GBTs and RDTs.

In-tank thickening for primary solids was not considered because the City does not want to continue the process. The City would like to use other alternatives that would provide a higher solids content to reduce the need for future digester expansions.

DAFTs were also not considered as one of the WAS alternatives because they have a high space requirement, and are a mechanically intensive process. They require numerous mechanical components such as compressors and a pressurized system to provide the dissolved air for floatation. In addition, they produce more dilute thickened sludge, which would significantly increase the required digester capacity.

4.4 SOLIDS PROJECTIONS

Table 3.1 summarizes the solids projections for the 52.2-mgd Annual Average Daily Flow (ADF) condition. The calibrated Biotran model was used to predict the future conditions.

Table 4.1 Solids Projections
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

52 mgd	Primary Sludge	Raw WAS
Solids, lbs/day	103,000	118,000
% Concentration	1.5	0.6
Max Month Flow, mgd	0.82	--
Peak Flow, mgd	1.34	2.36
VSS %	81	85

To ensure good performance by the mechanical thickeners, it is necessary to provide a continuous and consistent feed. With a continuous pumping operation, the primary sludge solids concentration is normally about 0.5 percent. However, this solids concentration would result in a very high primary sludge flow that would require many thickening units. In order to decrease the number of units required, a control system should be set up so that pumping would rotate among the primary sedimentation basins. This would allow the solids blanket to build up and provide continuous pumping of approximately 1.5 percent primary solids to the thickening facilities. Furthermore, in order to provide continuous pumping without storage, the primary thickening facilities would be based on the peak flow condition with a peaking factor of 1.8.

The WAS projection for the 52.2-mgd ADF condition was based on the historical data and the City's wasting record. The City could waste up to twice the average amount of WAS in order to adjust process control. The capacities for the secondary thickening facilities will allow the City to have this peak wasting flexibility.

4.5 EXISTING THICKENING FACILITIES CAPACITIES

As stated earlier, the existing thickening system includes in-tank primary sludge thickening. Primary sludge from Plant 1 is sent to the Plant 2 primary clarifiers where the sludge is thickened in-tank. From the Plant 2 primaries, the sludge is pumped to digestion.

WAS thickening is done using two DAFTs at the RWQCP. The design criteria for the DAFTs consist of a solids-loading rate of 18 lbs/day/sf (without polymer) and 24 lbs/day/sf (with polymer). It also requires a hydraulic loading rate of 0.5 gpm/sf. There are two 37-foot diameter DAFTs at the RWQCP, which have a combined effective surface area of 1,980 square feet. Based on the Biotran™ calibration, the plant is producing approximately 30,500 lbs/day of solids.

Based on the design criteria for the DAFTs and the current operating conditions, the capacity of the DAFTs (without polymer) with both units in service was estimated to be 36.3 mgd on an average daily flow basis (18.1 mgd with one unit out of service). Current plant average daily flow influent flow is approximately 33 mgd, so the DAFTs are operating near their rated capacity if the City does not add polymer to their DAFT operation. If polymer is added to the DAFTs, the City would have a capacity of 48.4 mgd with all units in service and about 24 mgd with one unit out of service.

4.6 THICKENING ALTERNATIVES

The new thickening facilities will be designed to include primary sludge and WAS thickening capabilities. For ease of O&M, it is preferred that the same type of thickening equipment be used for both primary sludge and WAS. It is assumed that the two existing DAFTs would be used to thicken scum once the new thickening facilities are installed.

As stated in Section 4.3, gravity thickening was considered as one of the alternatives for the primary thickening. Gravity thickening requires a high space requirement and can cause odors. Furthermore, gravity thickening is only suitable for primary sludge thickening. Since it is desirable to use the same type of equipment on both primary sludge and WAS, and the City staff did not have good experience with their gravity thickeners. This alternative was eliminated in the initial screening.

A centrifuge is an effective option for WAS thickening, whereas primary sludge is more suitable for gravity thickening because it contains abrasive material that can be detrimental to a centrifuge. Because of the desire to use the same equipment to thicken primary sludge and WAS, this option also was eliminated in the initial screening.

This leaves GBTs and RDTs as the two thickening options that would be evaluated for both separate and co-thickening for the master plan.

4.6.1 Design Criteria

Table 4.2 lists the design criteria for the GBTs and RDTs. The main design criterion that governs the design of GBTs and RDTs is the hydraulic loading rate. Manufacturers have claimed that GBTs can be operated at a hydraulic loading rate of up to 400 gpm per meter of belt width and 400 gpm per unit for RDTs. However, based on a series of phone surveys to existing installations, GBTs should not be designed at higher than 150 gpm per meter of belt width and 300 gpm per unit for RDTs. These criteria will be used for the RWQCP master plan.

Another criterion for GBTs is the solids loading rate, which is typically about 1,000 lbs/hr per meter of belt width. This criterion, however, is usually not the controlling parameter for GBTs.

Table 4.2 GBT and RDT Design Criteria[1]
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

Parameter	GBTs	RDTs
Hydraulic Loading Rate	150 gpm per meter	300 gpm per unit
Wash Water	60 gpm per meter	20 gpm per unit
Thickened Solids Concentration, %[2]	5 to 7	5 to 7
Solids Capture, %	90 to 95	90 to 95
Polymer Dose, Active lbs/dry ton	10 to 12	8 to 10

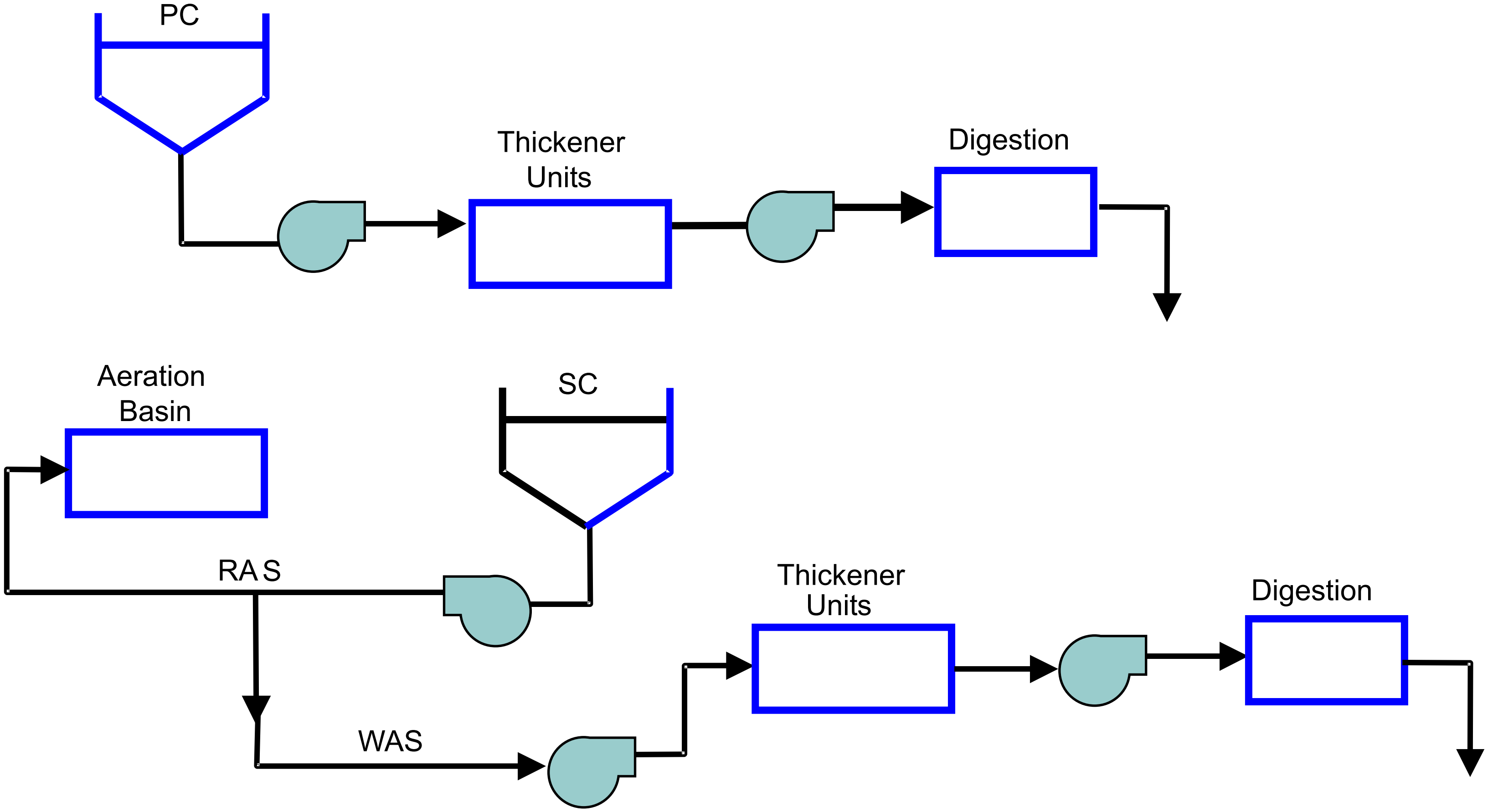
Notes:
(1) Assume same design criteria for separate thickening and co-thickening.
(2) Both GBTs and RDTs can thicken primary sludge to a much higher percentage, but are limited to this range for digestion purposes.

Furthermore, a 22-hour-per-day and 7-day-per-week operation schedule was assumed for the design.

4.6.2 Co-thickening versus Separate Thickening

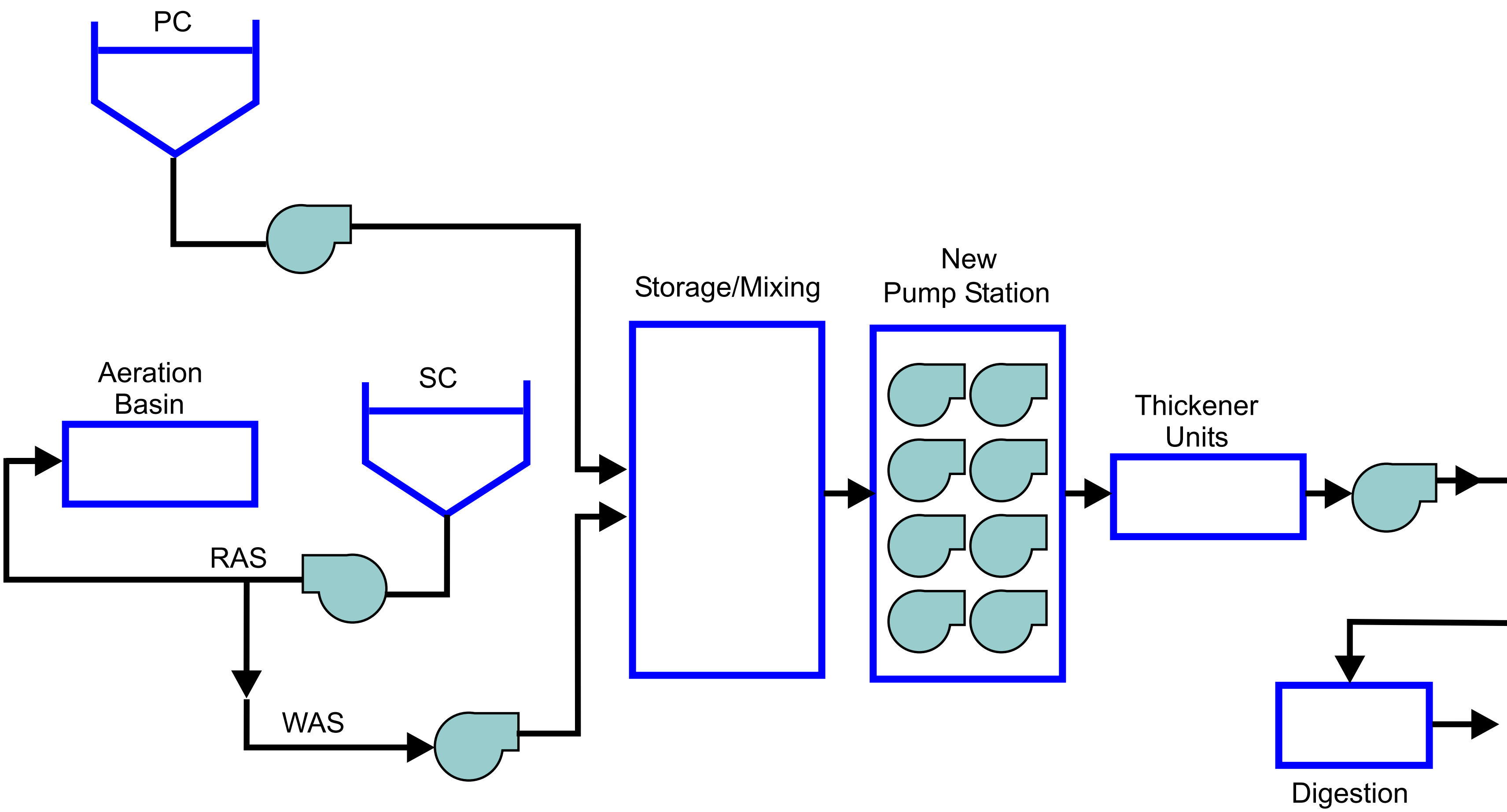
Figures 4.1 and 4.2 show flow schematics for separate thickening and co-thickening respectively. Co-thickening is mostly done in small facilities where they can reduce the number of mechanical equipment components. Since the design criteria are the same regardless of whether co-thickening or separate thickening is used, there are no savings in the number of thickening units for large facilities such as the RWQCP.

An advantage of co-thickening is that the addition of WAS to primary sludge would help to absorb some of the volatile fatty acids; which would help to reduce odor during the thickening process.



FLOW SCHEMATIC FOR SEPARATE THICKENING

FIGURE 4.1



FLOW SCHEMATIC FOR CO-THICKENING

FIGURE 4.2

A disadvantage of co-thickening is that the mechanical thickening components operate better with a consistent feed. Due to the variation in primary and WAS wasting, the primary sludge/WAS ratio varies a lot when blending the two types of sludge for thickening purposes. Also, primary sludge and WAS have very different characteristics and behave differently in thickening equipment. This makes it difficult to maintain the correct polymer dosage for the thickening process.

Furthermore, co-thickening would cost more than separate thickening because storage/mixing tanks are required to blend the primary sludge and WAS before it is sent to the thickening units. Odor control would also be required for the storage units. Additionally, an extra sludge transfer pump station would be needed to send the combined sludge to the thickening units. This would result in higher capital and O&M costs.

4.6.3 Alternative 1: Gravity Belt Thickener

GBTs operate similar to belt presses, but without the roller presses at the end. A GBT uses a slow-moving fabric belt to separate sludge solids from the liquid by gravity drainage and capillary suction forces, imparted by the fabric's interstitial voids. Usually, polymer is added to the solids in the feed pipe before the solids are fed into the inlet. The conditioned sludge is then fed down a gently sloped inlet ramp, with guide vanes and baffles, to uniformly disperse the solids across the width of the belt. Free water released from the solids drains through the fabric belt while the solids remain on top. The solids retained on the belt would first be scraped with doctor blades and deposited in a discharge hopper. The belt would then be cleaned by high-pressure water. For a 2-meter belt, it is estimated that the wash water requirement would be as high as 120 gpm per unit.

Using a 2-meter belt, and based on the solids hydraulic flow projection and the previously referenced design criteria, four GBT units are required for primary sludge thickening and seven GBT units are required for WAS thickening. Based on the moving mechanical reliability criteria, three standby units would also be required, which results in a total of 14 GBTs.

4.6.4 Alternative 2: Rotary Drum Thickener

An RDT works similar to a GBT, in which free water drains through a moving porous media while flocculated solids are retained on the media. However, an RDT uses a rotating screen instead of a belt. An RDT is different from a centrifuge in that a centrifuge does not have a filter media and operates at a much higher speed than an RDT. An RDT is internally fed with dilute sludge from a head-box after conditioning with polymer. The suspension is distributed onto the internal surface of the rotating screening cylinder and physically strained for the separation of free water. The RDT has a built-in spray backwashing system, controlled with programmable timers that can be optimized for each application. For RDTs, about 20 gpm per unit of wash water is required for continuous cleaning of the drum.

Similar to GBTs, four RDT units are required for primary sludge thickening, and seven RDT units are required for WAS thickening. Three standby units will also be required to meet the reliability criteria. A total of 14 RDTs would be required for the expansion project.

The same numbers (14 units GBT or RDT) of thickening equipment would also be required under the co-thickening option.

Table 4.3 summarizes the new thickening facilities requirement.

Table 4.3 New Thickening Facilities Capacity
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

	GBT(1)	RDT(1)
Number of Units(2)	11 + 3 (standby)	11 + 3
Wash Water Requirement	120 gpm per unit	20 gpm per unit
Polymer Dosage, active lbs/dry ton	10 to 12	8 to 10

Notes:
(1) GBT is based on a 2-meter belt at 300 gpm per unit. RDT is based on 300 gpm per unit.
(2) Based on a peak primary sludge and WAS hydraulic loading rate, and 22 hour-per-day, 7-day-per-week operation.

4.7 ALTERNATIVE COMPARISON

A comparison of non-economic factors for the two thickening alternatives is presented in Table 4.4. In general, both GBTs and RDTs are gaining popularity because of their efficient space requirements, low power usage, and moderate capital costs compared to other thickening processes. The performance of both alternatives is highly dependent on the solids characteristics and effective polymer dosing and mixing. The main difference is that GBTs have been used for thickening applications for over 25 years, while RDTs are relatively new pieces of equipment and have no installations for primary sludge thickening. In addition, RDTs may require sole-source procurement. RDTs, however, can be enclosed to control odors. Historically, GBTs were not usually enclosed, and therefore had odor issues and were not spill-proof. Ashbrook's GBT; however, can be enclosed and therefore odors can be contained and the cover can also provide improved "spill-free" operation. Another difference is that one RDT uses much less wash water (20 gpm versus 120 gpm of wash water required for a 2-meter GBT), which translates to higher recycle stream treatment costs.

Table 4.4	Comparison of Gravity Belt and Rotary Drum Thickeners Wastewater Collection and Treatment Facilities Integrated Master Plan City of Riverside

	Alternative 1: Gravity Belt Thickener	Alternative 2: Rotary Drum Thickener
Space Requirement	+	+
Long-Term Equipment Reliability	+	–
Sole Source Procurement	+	–
Polymer Addition Requirement	0	0
Backwash Downtime	+	+
Recycle Stream Treatment	–	+
Maintenance Requirement	+	+
Odor Control	+	+

Ratings:
+ = Positive comparative characteristic.
– = Negative comparative characteristic.
0 = Neutral comparative characteristic.

4.8 LIFE CYCLE COST ANALYSIS

A cost comparison of GBTs and RDTs for both separate thickening and co-thickening is presented in Table 4.5. Costs associated with recycle stream treatment make up about 70 to 75 percent of the (O&M) costs. The O&M costs for GBTs are higher than the RDTs due to the higher amount of wash water, which requires additional treatment. At the project meeting on January 24, 2007, the City decided to use GBTs because GBTs have been used for more than 25 years and their operation is similar to the belt filter presses. The City might still consider co-thickening in the future, but for this master plan, separate thickening is the chosen option.

Table 4.5	Life-Cycle Cost of Gravity Belts and Rotary Drum Thickeners Wastewater Collection and Treatment Facilities Integrated Master Plan City of Riverside

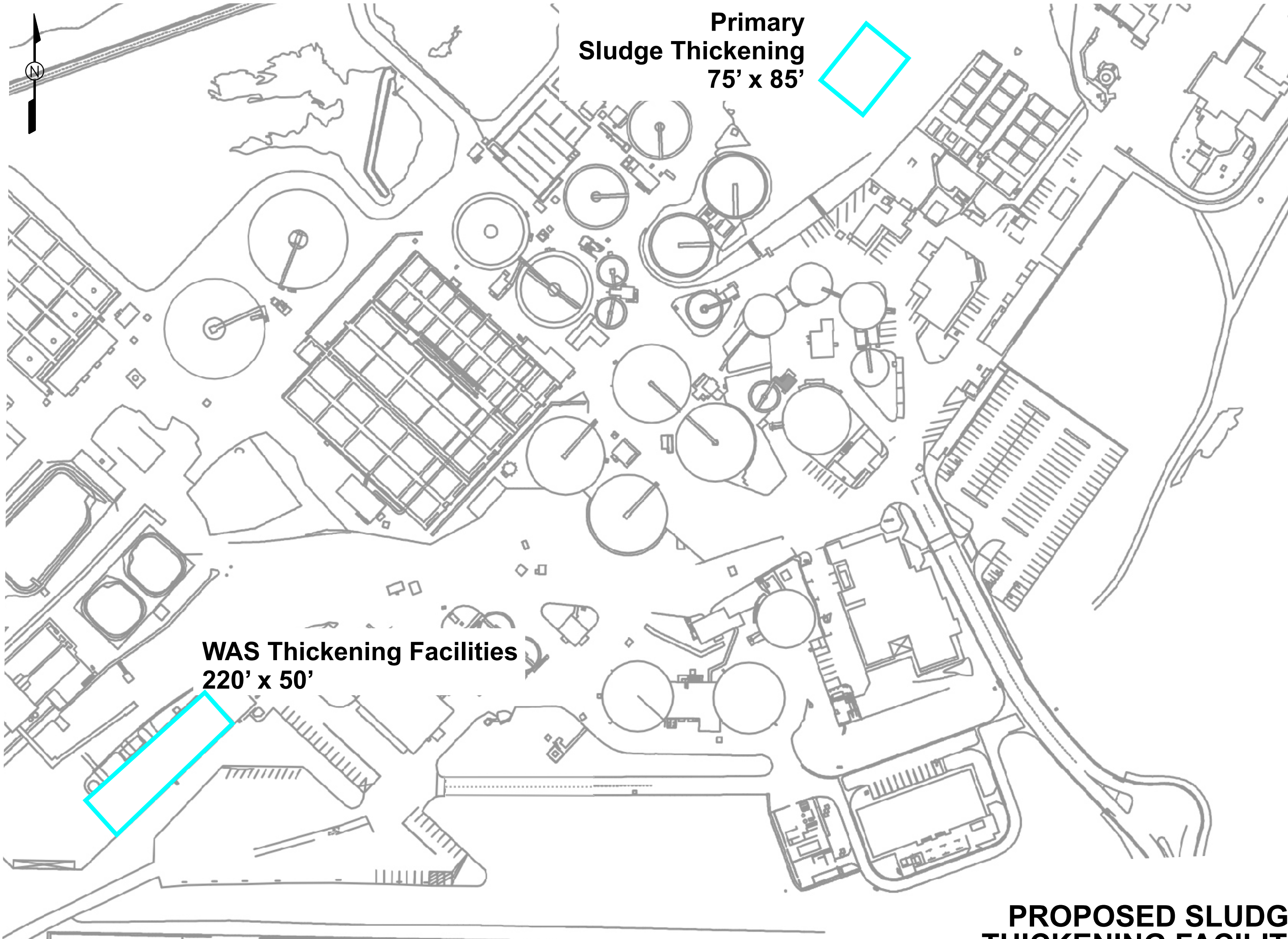
	Separate Thickening		Co-thickening(2)	
	GBT	RDT	GBT	RDT
Total Capital Cost(1)	$20,800,000	$24,200,000	$25,900,000	$29,300,000
Total Project Cost	$27,000,000	$31,400,000	$33,700,000	$38,000,000

Table 4.5	**Life-Cycle Cost of Gravity Belts and Rotary Drum Thickeners Wastewater Collection and Treatment Facilities Integrated Master Plan City of Riverside**			
	Separate Thickening		**Co-thickening**(2)	
	GBT	**RDT**	**GBT**	**RDT**
Annual O&M Cost(3)	$4,700,000	$3,700,000	$4,800,000	$3,800,000
Life-Cycle Cost(4)	$103,200,000	$90,700,000	$111,400,000	98,900,000

Notes:
(1) Total costs for thickener equipment, polymer blending unit, mechanical piping and valves, booster pump, filtrate pump station, building (metal), primary sludge pipe.
(2) Extra items added to co-thickening include: Retrofitting costs for DAFTs, covers for DAFTs, mixing system, sludge pump station.
(3) Includes the electrical cost, polymer cost, recycle treatment cost, and maintenance cost.
(4) As present value, assuming a life-cycle period of 19 years, a discount rate of 6 percent, and an escalation rate of 6 percent for the first 5 years and 4 percent thereafter.

4.9 PROPOSED SLUDGE THICKENING FACILITIES

Figure 4.3 shows a proposed layout of the thickening facilities using separate thickening facilities for primary sludge and WAS. The City plans to put the primary sludge thickening facilities near the Plant 1 primary clarifiers, while retrofitting the existing chemical building to house the nine WAS thickening units. The existing chemical building is currently not big enough to house all the necessary WAS thickening. Figure 4.3 shows a proposed layout of the new WAS thickening facility. As a result of the expansion of the building, the hypochlorite tanks will need to be moved from their current location. It is assumed that both thickening alternatives would require a similar amount of space. The area allocated is big enough to house all thickening units, polymer blending units, booster pumps and all other ancillary equipment.



PROPOSED SLUDGE THICKENING FACILITIES

FIGURE 4.3