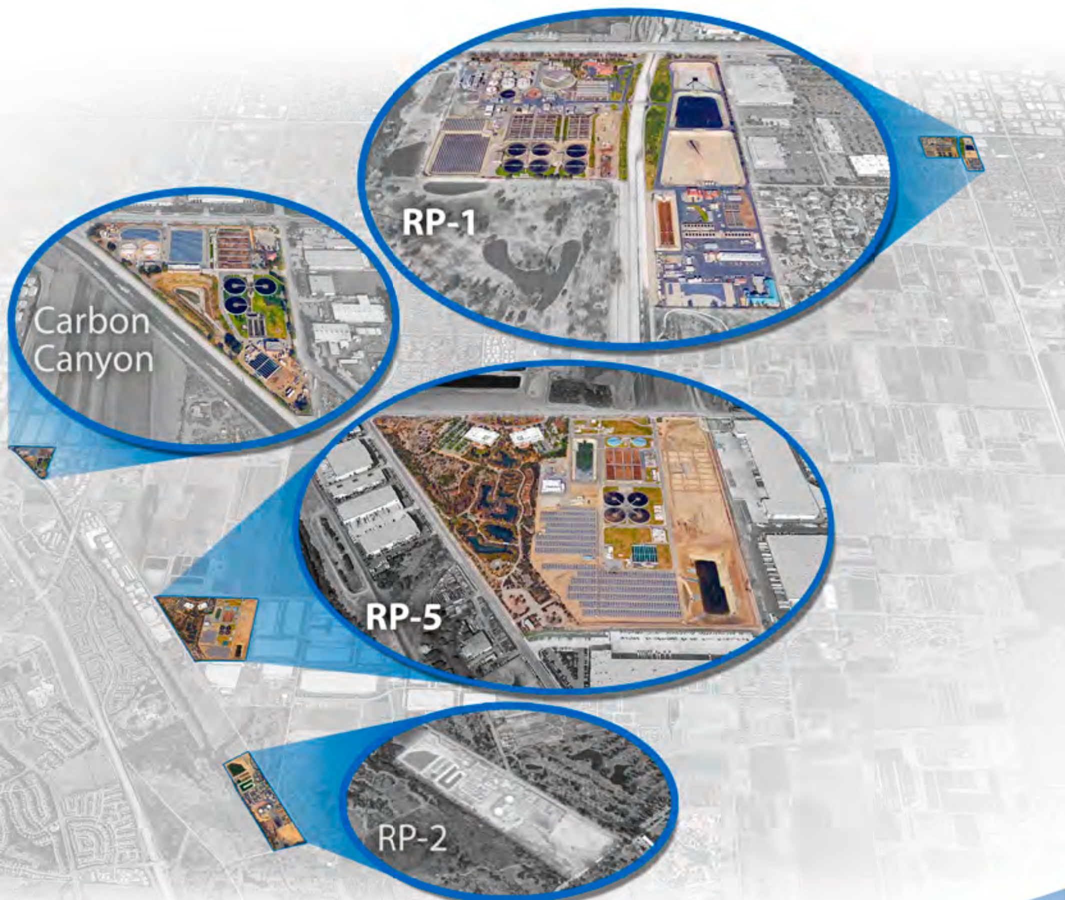
Inland Empire Utilities Agency
A MUNICIPAL WATER DISTRICT

Predesign Report Volume III
RP-5 Solids Treatment Facility

February 28, 2017



submitted by

PARSONS

in association with

Brown AND Caldwell

TABLE OF CONTENTS

APPENDICES

VOLUME I

VOLUME II

VOLUME III

EXHIBITS

VOLUME I

VOLUME II

VOLUME III

Inland Empire Utilities Agency
A MUNICIPAL WATER DISTRICT

Executive Summary for the RP-5 Solids Treatment Facility

Predesign Report
Volume III, Chapter 1

February 27, 2017

submitted by

PARSONS

in association with

Brown AND Caldwell

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

2-Phase	two-phase anaerobic digestion
AACE	American Association of Cost Engineers
ACH	air changes per hour
AHU	air handling unit
ANSI	American National Standards Institute
AOP	advanced oxidation process
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
AWWARF	American Water Works Research Foundation
BACT	best available control technology
BCE	business case evaluation
BFP	belt filter press
bgs	below ground surface
bhp	brake horsepower
BNR	biological nutrient removal
BOD	biochemical oxygen demand
Btu; BTU	British thermal unit
Cal-OSHA	California Occupational Safety and Health Administration
CAS	conventional activated sludge
CCR	California Code of Regulations
CCWRF	Carbon Canyon Water Recycling Facility
CEC	contaminant of emerging concern
CEQA	California Environmental Quality Act
CFD	computational fluid dynamics
cfm	cubic feet per minute
CIDS	Chino Interceptor Diversion Structure
CIP	clean-in-place
CIW	Chino Institute for Women
CM	construction management
CO	carbon monoxide
COD	chemical oxygen demand
D/T	dilution(s) to threshold
DAFT	dissolved air flotation thickener
DDW	Division of Drinking Water
deg F	degree Fahrenheit
DS	digested solids
EIR	Environmental Impact Report
EOP	Emergency Overflow Pond
EPA	Environmental Protection Agency
ESA	Environmental Site Assessment
ESB	Emergency Storage Basin
$FeCl_3$	ferric chloride
$FePO_4$	iron phosphate
FOG	fats, oils, and grease

fpm	feet per minute
FRP	fiberglass-reinforced plastic
ft	foot; feet
ft/min	feet per minute
ft^2	square foot; square feet
ft^3	cubic foot; cubic feet
ft^3/MG	cubic feet per million gallons
FTE	full-time equivalent
FW	food waste
G	gravitational unit
g/L	grams per liter
gal	gallon; gallons
GBT	gravity belt thickener
gfd	gallons per square foot per day
GHG	greenhouse gas
gpd	gallon(s) per day
gpm	gallon(s) per minute
G's	gravitational units
H_2S	hydrogen sulfide
HAP	hazardous air pollutant
HDPE	high-density polyethylene
HEX	heat exchanger
HGL	hydraulic grade line
hp	horsepower
hr	hour(s)
HSW	high-strength waste
HVAC	heating, ventilation, and air conditioning
I&C	instrumentation and controls
IBE	Inland Bioenergy
IC	internal combustion
IEBL	Inland Empire Brine Line
IEUA	Inland Empire Utilities Agency
in	inch(es)
inches w.c.	inches water column
kW	kilowatt
LAER	lowest achievable emission rate
lb	pound(s)
lb/d	pounds per day
lb/ft^2/hr	pounds per square foot per hour
lb/ft^3	pounds per cubic foot
lb/hr/m	pounds per hour per meter
lb/MG	pound(s) per million gallon
lb/MMBtu	pounds per million Btu
lb/MMBTU	pounds per million Btu
lb/ton	pounds per ton
m	meter(s)

MAD	mesophilic anaerobic digestion
MBR	membrane bioreactor
MCC	motor control center
MG	million gallons
mg/L	milligrams per liter
mgd	million gallons per day
min	minute(s)
mJ/cm^2	millijoules per square centimeter
ML	mixed liquor
MLR	mixed liquor return
MLSS	mixed liquor suspended solids
MM	maximum month
mm	millimeter
MMBTU	million British thermal units
MW	megawatt
NaOCl	sodium hypochlorite
NaOH	sodium hydroxide
NARUC	National Association of Regulatory Utility Commissioners
NFPA	National Fire Protection Association
NG	natural gas
NH_3-N	ammonia as nitrogen
NH_4	ammonium as nitrogen
NOx	nitrous oxide(s)
NPDES	National Pollutant Discharge Elimination System
NPV	net present value
NRW	non-reclaimable water
NTU	nephelometric turbidity unit
NWRI	National Water Research Institute
O&M	operation(s) and maintenance
ORC	organic Rankine cycle
OSHA	Occupational Safety and Health Administration
PAC	polyaluminum chloride
PDR	Pre-Design Report
PFD	process flow diagram
ppbv	part(s) per billion volume
ppd	pounds per day
ppm	parts per million
ppmv	part(s) per million volume
PS	pump station
psi	pound(s) per square inch
psig	pound(s) per square inch gage
PVC	polyvinyl chloride
R&R	repair and replacement
RAS	return activated sludge
rdoN	recalcitrant dissolved organic nitrogen
RDT	rotary drum thickener

REC	recognized environmental conditions
REEP	Renewable Energy Efficiency Project
RFP	Request for Proposal
RO	reverse osmosis
RP	Regional Water Recycling Plant
RP-1	Regional Water Recycling Plant 1
RP-2	Regional Water Recycling Plant 2
RP-4	Regional Water Recycling Plant 4
RP-5	Regional Water Recycling Plant 5
rpm	revolutions per minute
RW	recycled water
SARI	Santa Ana Regional Interceptor
SAWPA	Santa Ana Water Protection Authority
SCADA	supervisory control and data acquisition
SCAQMD	South Coast Air Quality Management District
SCE	Southern California Edison
scfm	standard cubic feet per minute
SCR	selective catalytic reduction
SHF	solids handling facility
SOR	surface overflow rate
SRF	State Revolving Fund
SRT	solids retention time
SSO	sanitary sewer overflow
STF	solids treatment facility
SVI	sludge volume index
SWD	side water depth
TDH	total dynamic head
TDS	total dissolved solids
THP	Thermal Hydrolysis Process Anaerobic Digestion
TIN	total inorganic nitrogen
TKN	total Kjeldahl nitrogen
TM	technical memorandum
TMP	trans-membrane pressure
TN	total nitrogen
TOC	total organic carbon
TPAD	temperature-phased anaerobic digestion
TPHD	thermal hydrolysis process anaerobic digestion
TS	total solids
TSS	total suspended solids
Two-Phase	two-phase anaerobic digestion
USA	United States of America
USACE	United States Army Corps of Engineers
UV	ultraviolet
UVT	ultraviolet transmittance
VFA	volatile fatty acid(s)
VFD	variable frequency drive

VOC	volatile organic carbon; volatile organic compound
VS	volatile solids
VSR	volatile solids reduction
VSS	volatile suspended solids
WAS	waste activated sludge
WFMP	Wastewater Facilities Master Plan
wk	week
WWTP	wastewater treatment plant
yr	year

CHAPTER 1: EXECUTIVE SUMMARY

1.1 INTRODUCTION

Volume III of the Pre-Design Report (PDR) includes discussion on subjects directly or indirectly related to the expansion of Regional Water Recycling Plant #5 (RP-5) solids treatment processes:

- Chapter 3: Evaluation of the Decommissioning of RP-2
- Chapter 4: Evaluation of the Relocation of the RP-2 Lift Station
- Chapter 5: Evaluation of the Relocation of Inland Empire Brine Line (IEBL) Discharge Station
- Chapter 6: Evaluation of Off-Site Recycle Flow Discharge
- Chapter 7: Evaluation of RP-5 Solids Treatment Alternatives
- Chapter 8: Evaluation of Food Waste Treatment System
- Chapter 9: Evaluation of Beneficial Use of RP-5 Digester Gas

In each chapter, different alternatives were considered and if required, business case evaluations (BCEs) were developed to compare the alternatives (Exhibit 1).

1.2 EVALUATION OF THE DECOMMISSIONING OF RP-2

Regional Plant No. 2 (RP-2) is located in the city of Chino within the flood zone upstream of the Prado Dam, on land leased from the United States Army Corps of Engineers (USACE). To increase the available Orange County water storage, USACE will increase the maximum operational water level upstream of the dam by raising the Prado Dam Spillway. This increase will cause RP-2 to be within the 566-foot inundation area.

In accordance with the easement renewal for the right-of-way for RP-2 granted by USACE that extended the easement term from May 9, 2010 to May 8, 2035, IEUA is required to remove RP-2 facilities and restore the plant site and utilities upon expiration or termination of the easement. The decommissioning of the plant facilities must follow USACE and US Environmental Protection Agency (EPA) requirements supplemented by state requirements.

Chapter 3 of this volume presents preliminary cost estimates of demolishing the facilities at RP-2 and requirements for restoring the site and utilities. The elements addressed for decommissioning and performing demolition activities include the following:

- Identification of infrastructure and equipment to be removed and preliminary demolition cost estimates
- Environmental Site Assessment (ESA) for the identification and sampling of recognized environmental conditions (RECs) in the soil, surface water, and groundwater. Phase I ESA has been completed and is provided in Volume IV of this PDR.
- Hazardous Waste Survey for the identification and sampling of any buildings or materials that are suspected of containing hazardous materials.
- Regulatory coordination with affected agencies: USACE, Regional Water Control Board (RWQCB), Santa Ana Water Protection Authority (SAWPA), California Occupational Safety and Health Administration (Cal-OSHA), City of Chino, and South Coast Air Quality Management District (SCAQMD).
- Identification of required permits and notifications.

- Liquids, biosolids, solid waste, and industrial waste management and disposal.
- Site restoration requirements.

The worst-case scenario costs are as high as $42.5 million with respect to the potential costs of hazardous materials abatement and soils remediation, as detailed in Volume III Chapter 3. These costs are expected to be determined with greater accuracy during the Phase II ESA and Hazardous Materials Survey.

1.3 EVALUATION OF THE RELOCATION OF THE RP-2 LIFT STATION

The existing RP-2 lift station receives raw sewage from the 24-inch diameter Mountain Avenue interceptor sewer, 10-inch diameter Chino Institute for Women (CIW) sewer, 10-inch-diameter Butterfield force main, and recycled flows from the solids treatment facilities at RP-2. The 10-inch-diameter CIW sewer receives sewage flows from both the CIW and the El Prado Golf Course clubhouse. Each pump discharges into a 14-inch-diameter discharge pipe connecting to a 24-inch-diameter discharge manifold that conveys flows to the RP-5 headworks.

Due to the anticipated decommissioning of RP-2, the lift station must be relocated above the Prado Dam inundation area above elevation 566, and the associated collection/discharge system must be modified to account for these changes.

As discussed in Chapter 4, the collection system will be modified so that the CIW flows and golf course will be handled separately in a joint agreement with City of Chino. Thus, the flows to be received and pumped at the new location include the Mountain Avenue Sewer, which will be renamed as the Mountain Avenue Lift Station. The Butterfield Ranch lift station flows are discussed below, and will be combined with the discharge of the Mountain Avenue Lift Station.

The Butterfield Ranch Lift Station, located about 2 miles south of RP-2 as shown in Figure 1-1, is owned and operated by the City of Chino Hills. Due to the anticipated decommissioning of RP-2, the flows from Butterfield Ranch will have to be conveyed to the Kimball Avenue Interceptor as illustrated in Figure 1-1, combining the Butterfield Ranch peak flows of about 1,100 gpm with the Mountain Avenue flows of up to 560 gpm. The Butterfield Ranch force main will be extended by 3,000 feet of 10-inch diameter, followed by 3,200 feet of 12-inch force main once the flows are combined with the new lift station for Mountain Avenue.

The Butterfield Ranch lift station pumps, motors, and electrical system will be modified for the additional power requirements to achieve the additional pump discharge head required to pump the additional distance and to a somewhat higher elevation. The details of these modifications will be determined during the design phase when the current and future flows are confirmed with the City of Chino Hills.

1.4 EVALUATION OF THE RELOCATION OF THE IEBL DISCHARGE STATION

The existing IEBL Discharge Station is currently located at the RP-2 site along El Prado Road, near the intersection with the southern end of Mountain Avenue. The IEBL Discharge Station is a septage receiving station that receives trucked liquid waste from permitted haulers and discharges the waste to the 27-inch diameter IEBL (previously known as the Santa Ana Regional Interceptor [SARI]) on El Prado Road. Due to the anticipated decommissioning of RP-2, the station may be relocated to a site within the Agency-owned Solids Handling Facility at Mountain Avenue and Flower Street, as discussed in Chapter 5 of this volume.

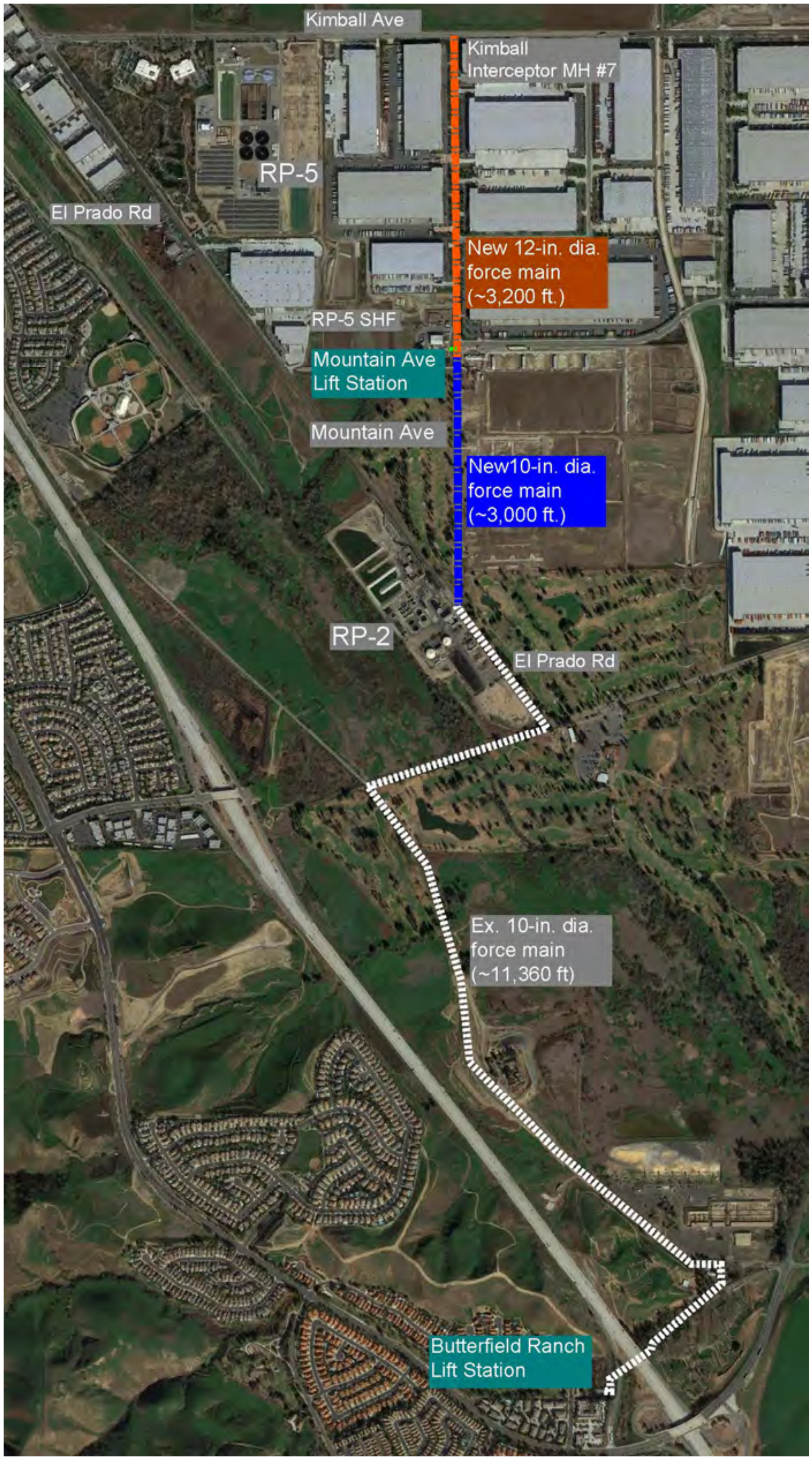


Figure 1-1: New Force Mains Locations

The IEBL Discharge Station will feature a dump station manhole, which receives septage/permitted liquid waste from two receiving stations, and two catch basins that capture any stormwater and spray-down waste. Each receiving station will include a quick disconnect coupling where hauling trucks can connect in order to discharge the waste. The incoming waste is analyzed for pH, temperature, conductivity, and sulfide, ensuring that the waste does not surpass the IEBL disposal limits. A magnetic flow meter and automatic sampler will be provided in the station. The dump station manhole will route septage/liquid waste through an 8-inch-diameter pipeline to the 27-inch-diameter IEBL. In this design, the septage is contained and odors are limited from escaping into the atmosphere.

1.5 EVALUATION OF OFF-SITE RECYCLE FLOW DISCHARGE

Centrate equalization and return to the primary influent splitter box will be provided for centrate from the dewatering treatment facility at RP-5. Centrate is a nutrient-rich residual stream produced by dewatering digestate. The stream is recycled to the head of the liquid stream treatment train and can represent 15% to 25% of the total nutrient load. To minimize the impact of centrate recycle to the secondary system, an equalization tank will be provided to evenly distribute the centrate over a 24-hour period. Centrate can also be returned to the liquid stream in a diurnal pattern to increase periods of low nutrient loading.

The centrate equalization tanks receive centrate 5 days/week during the 8-hour dewatering shift. Centrate will be stored in the equalization tanks and recycled to the liquid stream process at a constant rate over a 24-hour period. Two equalization tanks will be provided to allow one tank to be temporarily taken offline for cleaning or maintenance. Each tank will use a variable frequency drive (VFD) controlled mixer to keep particulates in suspension. A VFD driven feed pump controls centrate flow back to the liquid stream.

Centrate equalization tanks can be a source of odor; therefore, air from the headspace of the tanks will be collected and treated in the centralized odor treatment system. The amount of foul air will be sized to maintain a slight negative pressure within the tank preventing odorous air emissions to the atmosphere.

1.6 EVALUATION OF RP-5 SOLIDS TREATMENT ALTERNATIVES

RP-5 Solids Treatment Facility will be constructed to support an average plant capacity of 30 mgd, the projected 2035 flows for both CCWRF plus RP-5. The facility infrastructure will be sized to accommodate future expansion to 40 mgd. This section briefly describes all new solids process facilities required to achieve 30-mgd capacity.

1.6.1 Thickening

The new solids treatment facility at RP-5 will received primary sludge and waste activated sludge (WAS) generated at RP-5 and the Carbon Canyon Water Recycling Facility (CCWRF). A new solids thickening building will be constructed as part of Phase 1. The separate primary sludge and WAS streams from each facility (RP-5 and CCWRF) will be blended into a homogenous mix to be co-thickened. Consideration must be given to in the future being able to thicken streams separately.

Rotary drum thickener (RDT) was the selected technology for RP-5 solids thickening. In rotary drum thickeners the incoming sludge is mixed with polymer and flocculated to enhance particle separation before being introduced into a slow rotating screen. Filtrate from the RDTs drains through the screen openings and collects in a trough underdrain. Thickened sludge is conveyed through the rotating drum and out the discharge end via a continuous internal screw or angled flights.

The thickening facility will house a total of seven RDTs at build-out. Phase 1 will consist of the installation of five RDTs (four duty, one standby). Each RDT will have a dedicated sludge feed pump and polymer feed pump. Therefore, five sludge feed pumps and five polymer feed pumps will be installed during Phase 1, with space allocated for the future pumps in the pump room and polymer room. The polymer system will have one bulk storage tank, two makeup units, and two aging tanks to allow for one to be down for maintenance.

Rotary drum thickeners will be fully enclosed and provided with foul air take-off connections to tie into the odor scrubber system to help reduce odors from this area. Point source control of odors greatly reduces the amount of foul air and ultimately the size of the odor treatment system. Sludge storage tanks and filtrate tanks will also be ventilated to reduce the potential for odor and corrosion.

1.6.2 Anaerobic Digestion and Hot Water System

Two-phase anaerobic digestion (2-phase acid/gas) with thermophilic temperatures in the gas phase digestion was the selected technology for RP-5 solids digestion. Acid/gas (2-phase) digestion is a two-stage anaerobic digestion process comprising acid- and gas-phase anaerobic digesters. Acid-phase digestion is the first digestion phase, and is operated with a short solids retention time (SRT) of 1 to 1.5-days, during which the substrates are hydrolyzed to produce volatile fatty acids (VFAs). In the second digestion phase, methanogens are grown on the VFAs, which require a longer SRT of 14 days and are thus excluded from this acid-phase digester (aka acid silo). Although the second digestion phase can be operated at either thermophilic or mesophilic temperatures, the intended operation will be thermophilic (typically 131°F). This separation in phases has been demonstrated through long-term operation by IEUA to improve solids reduction and increase gas production.

One new acid phase anaerobic (acid phase) digester and three new thermophilic gas phase anaerobic (gas phase) digesters and a solids storage tank/gas phase digester will be constructed as part of Year 2035 (Phase 1). A second acid phase digester and two additional thermophilic gas phase anaerobic digester may be installed for the 2060 build-out requirements. Space has been reserved on site for these future facilities; it should be noted, however, that other technologies or innovations may be widely proven in the interim period, which might preclude the need to construct this additional tankage. Examples include the process of recuperative thickening, which provides an increase in SRT without additional tankage, as currently planned for RP-1.

Digester gas generated by the digesters will be used for gas utilization equipment, specifically cogeneration (Renewable Energy Efficiency Project [REEP] facility), and/or the plant's central heating facility boilers. Digester gas that cannot be used by either of these end uses would be disposed of in waste gas flares. A central heating facility housing new boilers will be provided and will use natural gas, or digester gas if available, to provide additional heat for the digestion process. The boilers for the new central heating facility would include three hot water boilers. Flexible water-tube boilers are recommended for this application because the flexible tubes are tolerant of thermal cycling and other WWTP's have reported less siloxane buildup compared to fire-tube boilers. The boilers shown are of adequate size to meet 2035 heat demands. Adequate floor space and ventilation in the boiler room would be included to permit larger boilers to replace the proposed boilers in the future, if necessary, to meet future heat demands.

1.6.3 Struvite Control Systems

Struvite is a magnesium ammonium phosphate mineral (Mg NH_4PO_4 +$6H_2O$) with the characteristics of a white crystalline solid. Under the digestion process, ammonia and phosphorus are released and if sufficient magnesium is present, struvite may form in the anaerobic digester tanks, digested sludge piping, and downstream dewatering equipment and centrate piping. Once formed struvite may coat the interior surfaces of tanks, piping and dewatering equipment which reduces efficiencies, and can be difficult and costly to remove. Ferric Chloride ($FeCl_3$) has been shown to be effective in struvite control by binding phosphorous (PO_4) to form iron phosphate ($FePO_4$). Ferric chloride has also been demonstrated to reduce hydrogen sulfide (H_2S) concentrations in digesters.

IEUA stores a 38% solution of ferric chloride at the primary chemical facility in a single fiberglass reinforced concrete containment area. To precipitate phosphorus and inhibit struvite from forming, a 38% ferric chloride solution will be metered into an injection point prior to either or both the acid and gas phase digesters. A day tank and meter pump will be provided for ferric chloride injection at the two-phase digestion facilities. The ferric chloride dosing facilities at the 2-phase digestion process will be sized for both ortho-phosphorous and sulfur removal. Although ortho-phosphorous is the primary target, the presence of hydrogen sulfide will compete for ferric chloride and result in additional ferric chloride demand.

1.6.4 Dewatering, Cake Transfer, Storage, and Loadout

Centrifuges are the preliminary selected technology for RP-5 solids dewatering. A centrifuge is composed of two cylinders, rotating at slightly different speeds. In the outer cylinder, centrifugal force propels the heavier digested solids to the wall of the outer cylinder at accelerations of approximately 3,000 gravitational units (Gs). Centrate, the remaining residual liquid, accumulates along the axis of rotation and is discharged over a concentric weir. The inner cylinder has a scroll encircling its outer surface. Because the inner cylinder rotates at a slightly slower rotational speed than the outer cylinder (the differential), the scroll moves along the inner surface of the outer cylinder, conveying the dewatered solids to a dewatering beach, and then to its discharge. The liquid centrate is conveyed via an overflow weir to a liquid drain.

Four centrifuges will be constructed as part of Year 2035 (Phase 1). The centrifuges will be sized to dewatering both digested sludge from RP-5 and food waste digestate from the Solids Handling Facility (SHF). In order to provide redundancy for dewatering operations to maintain required capacity during extended maintenance events, one full standby dewatering unit along with all ancillary equipment will be provided. Supporting systems such as polymer, feed pumping, cake pumping and electrical will be designed to allow for operation of all dewatering units (including standby) to operate simultaneously in order to provide maximum operational flexibility in the event that plant operators decided to temporarily operate at a higher dewatering system throughput than the design basis.

Three days of upstream digested sludge storage is provided in the digested sludge storage tank to eliminate the need for dewatering shifts during 3-day weekends and also to provide additional operational flexibility for the dewatering system. The digested sludge storage tank will also serve as a redundant anaerobic digester to provide additional digestion capacity during maintenance operations.

One day of storage is provided in the cake storage bins to facilitate truck loadout. Two 6,000-cubic-foot (ft^3) cake bins provide redundancy and allow trucks transfer.

Dewatering centrifuges are totally enclosed and equipped with foul air takeoff connections on the unit housings, centrate chutes and the solids chutes. It is also recommended that foul air connections be provided on all conveyors used to move solids between processes because they can be a significant odor source. Point source control of odors greatly reduces the quantity of foul air and ultimately the size of the odor control system. The foul air extracted from processes in the dewatering building will be conveyed to the centralized odor control facility.

1.6.5 Biogas Conditioning and Utilization/Waste Gas Burners

Waste gas burners are required anaerobic digestion safety equipment used for eliminating excess biogas. The selection of two-phase anaerobic digestion technology for RP-5 solids digestion will produce two separate biogas streams. The first phase or acid-phase will generate a relatively small amount of lower quality gas containing methane, carbon dioxide (CO_2) and H_2S. The second digestion phase will be a thermophilic (digester) process and will generate a gas with favorable methane concentrations for beneficial utilization; in the REEP or the boilers.

Ultra-low emissions enclosed flares have a similar configuration to standard enclosed combustion flares in regard to the flaring section with an enclosed tower that promotes flame stability. Where the ultra-low emissions flare differs is the addition of specialized combustion air blowers and an extended fuel/air pre-mixing section upstream of the flare to ensure a consistent homogenous air/fuel mixture. These blowers bring in additional air that is blended with the biogas prior to combustion resulting in lower emissions of criteria pollutants.

To meet air permitting regulations, two ultra-low emissions enclosed flares were the selected waste gas flaring alternative. The recommended configuration combines the acid-phase and the digester gas streams into a single flow stream which can then either be flared or beneficially used.

1.6.6 Odor Control

The solids facilities, including thickening, dewatering, cake storage and truck loadout, and centrate equalization will require odor control. Odor control ducts from each facility will be routed to a centralized facility designed to treat foul air from both the liquids and solids process facilities.

1.7 EVALUATION OF RP-5 FOOD WASTE TREATMENT SYSTEM

Food waste is currently accepted at RP-5 SHF for processing, digestion, and dewatering. As part of this project, all food waste will continue to be processed at RP-5 SHF, and digestate from SHF will be pumped to RP-5 for dewatering. A new food waste receiving station, capable of receiving an average of 50,000 gallons per day (gpd) of pre-processed slurry, will be constructed at the RP-5 SHF, including a truck unloading pad, transfer/mixing pumps, storage tanks, and digester feed pumps. After digestion at RP-5 SHF, digestate will be pumped via a new transfer pump station and pipeline to the digested sludge storage tank at RP-5, where it will be dewatered along with the biosolids digestate. Dewatering food waste digestate in addition to the biosolids digestate will require an additional centrifuge, larger cake storage, and larger centrate equalization tanks. The main drivers for accepting food waste at RP-5 SHF only and routing digestate back to RP-5 are as follows:

- Avoidance of potential for digester upsets at RP-5 due to inconsistent food waste composition
- Elimination of dewatering operations at RP-5 SHF, which have reportedly been a bottleneck due to limited capacity
- Economies of scale associated with dewatering both digested solids streams together (food waste digestate from SHF and biosolids digestate from RP-5)
- Avoidance of costs associated with centrate discharge to IEBL at RP-5 SHF

1.8 EVALUATION OF BENEFICIAL USE OF RP-5 DIGESTER GAS

The digester gas produced from biosolids digestion at RP-5 and food waste digestion at RP-5 SHF will be beneficially used in a digester gas utilization facility. Currently, digester gas from the RP-5 SHF is used at the RP-5 REEP, which consists of two internal combustion (IC) engines.

As part of this project, digester gas from the new RP-5 Solids Treatment Facility (STF) will be combined with digester gas from SHF and used in the existing two IC engines for power generation and heat recovery. RP-5 digester gas will require gas conditioning, including H_2S removal, moisture removal via refrigeration, and siloxane removal. With additional food waste deliveries at SHF, the RP-5 SHF digester gas quantity is anticipated to increase, so the existing H_2S removal system at SHF will require expansion with two iron sponges similar to the existing. In addition, exhaust from the IC engines requires treatment to comply with SCAQMD NOx emission limits per Rule 1110.2. Thus, two selective catalytic reduction (SCR) units will be installed – one for each of the engines. Finally, the existing REEP heat recovery system requires modifications to allow heat produced in the engines to be used for RP-5 digester heating. These modifications will include hot water piping and heat exchangers.

1.9 SITE LAYOUT

The complete site layout for the approved expansion project, including space allocation for future processes, is shown in Figure 1-2.

1.10 PERMITTING

Required permits include the following:

- Permits for on-site facilities:
  - City of Chino building permit (IEUA may be exempt from local requirements for wastewater treatment process related facilities)
  - Chino Valley Fire District fire protection permit
  - State Water Resources Control Board waste discharge requirements amendment
  - South Coast Air Quality Management District air quality permit to construct
  - Title 22 Permit Update

- Permit for Off-Site Facilities:
  - City of Chino Public Works Department encroachment permit for new pipelines in public rights-of-way
  - City of Chino Hills building permit (for the Butterfield Lift Station upgrade)

1.11 PROJECT SCHEDULE

The project milestone schedule is shown in Table 1-1.

Table 1-1: Project Milestone Schedule

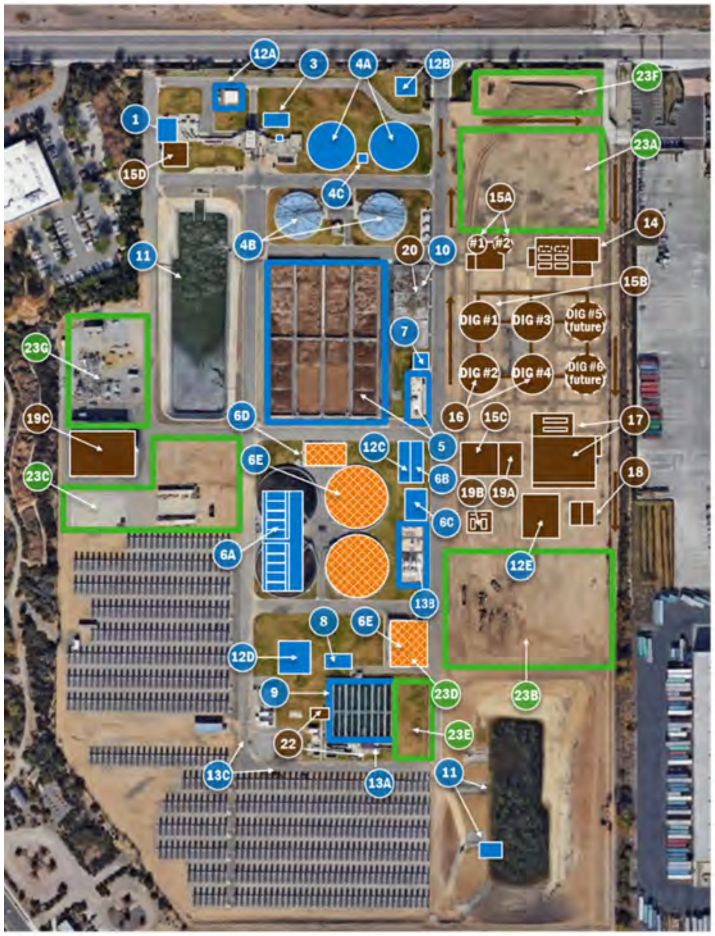
Project Milestone	Target Date (mm/dd/yyyy)
Design Contract Board Award/Approval	04/19/2017
30% Design Completion	11/01/2017
50% Design Completion	04/01/2018
85% Design Completion	11/01/2018
100% Design Completion	04/01/2019

1.12 OVERALL PROJECT COST ESTIMATE

The overall solids treatment project cost estimate is shown in Table 1-2.

Table 1-2: Solids Treatment Approved Project Cost Estimate

Major Systems	Estimated Cost
Thickening	$10,426,000
Digestion	$51,632,000
Dewatering	$42,912,000
Odor Control	$1,882,000
Digester Gas Treatment, Flaring, and Emissions Controls	$9,992,000
Permanent Power System Expansion	$2,064,000
Site Work	$7,875,000
Food Waste System	$9,411,000
Estimated Construction Cost	**$135,383,000**
Design & Project Management (20%)	**$27,076,000**
Total Project Cost	**$162,459,000**



Liquids

1. Influent Pump Station
2. Chino Interceptor Sewer Protection System (not shown)
3. Headworks
4A. New Primary Clarifiers
4B. Aluminum Flat Covers on Existing Clarifiers
4C. New Primary Effluent Diversion Structure
5. Modifications to Existing Aeration Basins - Includes: replacement of existing diffuser system, replacement of aeration blowers, addition of air piping, and installation of submersible mixers
6A. Membrane Tanks and Equipment Building
6B. New Aeration Blowers and Building
6C. New backpulse & CIP systems
6D. Demolition of RAS/WAS Pump Station
6E. Demolition of Secondary Clarifiers
6F. Demolition of Tertiary Filters
7. Methanol Injection System
8. Disinfection Facility - Includes: New UV treatment system
9. Convert to Recycled Water Storage
10. Liquids & Solids Odor Control
11. Off-Specification and Emergency Storage - Includes: interconnection of the two storage basins, new pump station at the EOP, lining the EOP, and repair of concrete and seals in the ESB
12A. Modifications to Power Center 1
12B. Power Center 1A
12C. Power Center 2A
12D. Power Center 3A
12E. Power Center 4
13A. Replacement of air relief valve in Recycled Water Pump Station
13B. Shading of chemical storage area
13C. Install curb and gutter along the west and south roads

Solids

14. Solids Thickening
15A. Acid-phase Digesters
15B. Methane-phase Digesters
15C. Hot Water Boiler
15D. Ferric Chloride Transfer Pump Station
16. Digested Sludge Storage
17. Dewatering and Cake Storage
18. Centrate Equalization and Pumping
19A. Gas Purification System
19B. Enclosed Flares
19C. Selective Catalytic Reduction on IC Engine Exhaust
20. Solids Train Odor Control (combined with liquids)
21. RP-5 Food Waste Treatment Facility (not shown)
22. Utility System Expansions

Site Plan

23A. Side stream centrate treatment, food waste/FOG receiving, thickening building expansion, future solids treatment processes
23B. Operations and Maintenance Building
23C. Parking Area/Digester Gas Utilization Equipment
23D. Advanced Water Treatment System
23E. Expanded Recycled Water Pumping
23F. CNG/RNG Station
23G. Lab

W17-0014-002

Figure 1-2: RP-5 Approved Expansion Project Site Layout

Inland Empire Utilities Agency
A MUNICIPAL WATER DISTRICT

Approved Project Requirements for RP-5 Solids Treatment Facility

Predesign Report
Volume III, Chapter 2

February 28, 2017

submitted by

PARSONS

in association with

Brown AND Caldwell

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

CHAPTER 2: APPROVED PROJECT REQUIREMENTS

2.1 INTRODUCTION

The Wastewater Facilities Master Plan (WFMP) of 2013 evaluated and concluded that RP-5's existing wastewater treatment capacity would be exceeded by the year 2025. Additionally, the solids loading from Carbon Canyon Waste Recycling Facility (CCWRF) and RP-5 already exceeds the digester capacity at RP-2, where these solids streams are currently treated. Due to the United States Army Corps of Engineers (USACE) project to raise the Prado Dam Spillway, the RP-2 solids treatment facility will need to be decommissioned and a new RP-5 solids treatment facility constructed with a design capacity to treat the projected flows.

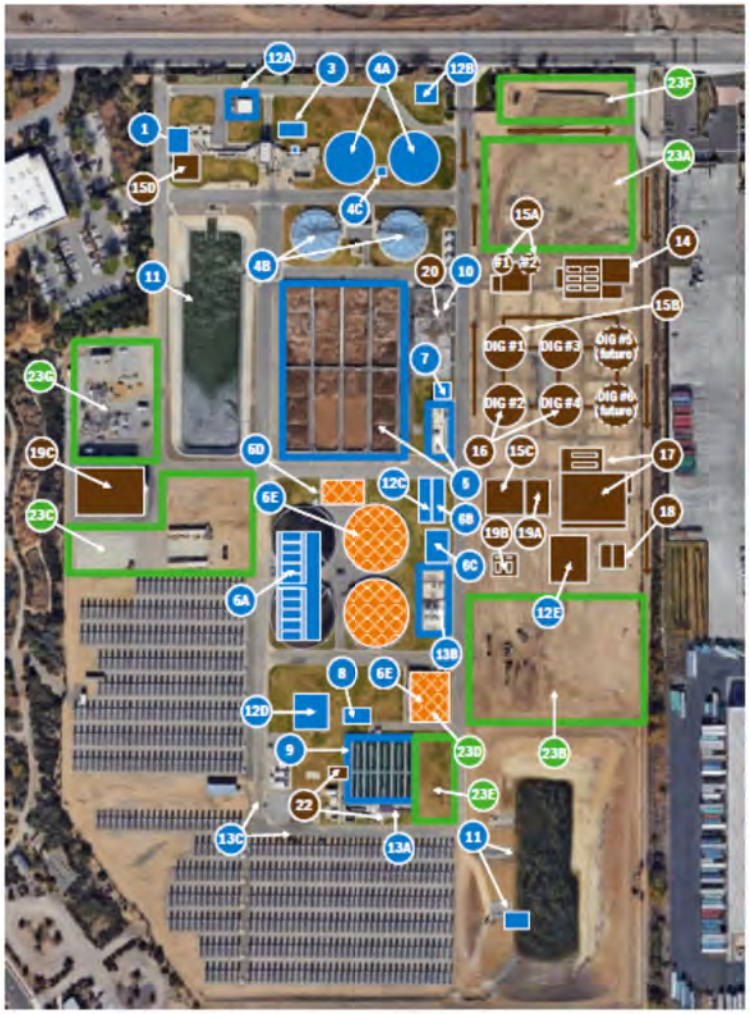
In Chapter 2, RP-5 facility needs were combined with needs arising from service area expansion and level of service requirements to generate a list of preliminary design decisions. Each decision was granted a set of alternatives, which were assessed using business case evaluations, recommendations from workshops, and direction and preferences identified by IEUA. The evaluations and recommendations led to the advancement of selected alternatives. The IEUA standard business case evaluation (BCE) template was utilized to develop comparative net present values for solids facilities with construction starting in 2022 and operating through 2035.

In this chapter, the selected alternatives are integrated into a preliminary design of the RP-5 Solids Treatment Facility. This chapter summarizes the basis of design of each unit process, presenting design criteria and details of how each system fits into the overall operation of the Plant.

2.1.1 Description of Approved Project Solids Treatment Facility

The RP-5 Solids Treatment Facility will be located east of secondary and tertiary treatment processes at RP-5. As shown on Figure 2-1, the new RP-5 facility foot print comprises an area of approximately 7 acres. The chosen technologies for RP-5 solids treatment include:

- Rotary drum thickening
- Two-phase (acid/gas) digestion
- Centrifuge dewatering
- Centrate equalization
- Biogas conditioning, waste gas burners, and hot water boilers
- Cogeneration engine exhaust treatment and heat recovery system
- Food waste receiving facility at the SHF site (space allocated for future FW receiving at RP-5)



Liquids

1. Influent Pump Station
2. Chino Interceptor Sewer Protection System (not shown)
3. Headworks

4A. New Primary Clarifiers
4B. Aluminum Flat Covers on Existing Clarifiers
4C. New Primary Effluent Diversion Structure

5. Modifications to Existing Aeration Basins - Includes: replacement of existing diffuser system, replacement of aeration blowers, addition of air piping, and installation of submersible mixers

6A. Membrane Tanks and Equipment Building
6B. New Aeration Blowers and Building
6C. New backpulse & CIP systems
6D. Demolition of RAS/WAS Pump Station
6E. Demolition of Secondary Clarifiers
6F. Demolition of Tertiary Filters

7. Methanol Injection System
8. Disinfection Facility - Includes: New UV treatment system
9. Convert to Recycled Water Storage
10. Liquids & Solids Odor Control
11. Off-Specification and Emergency Storage - Includes: interconnection of the two storage basins, new pump station at the EOP, lining the EOP, and repair of concrete and seals in the ESB

12A. Modifications to Power Center 1
12B. Power Center 1A
12C. Power Center 2A
12D. Power Center 3A
12E. Power Center 4
13A. Replacement of air relief valve in Recycled Water Pump Station
13B. Shading of chemical storage area
13C. Install curb and gutter along the west and south roads

Solids

14. Solids Thickening

15A. Acid-phase Digesters
15B. Methane-phase Digesters
15C. Hot Water Boiler
15D. Ferric Chloride Transfer Pump Station

16. Digested Sludge Storage
17. Dewatering and Cake Storage
18. Centrate Equalization and Pumping

19A. Gas Purification System
19B. Enclosed Flares
19C. Selective Catalytic Reduction on IC Engine Exhaust

20. Solids Train Odor Control (combined with liquids)
21. RP-5 Food Waste Treatment Facility (not shown)
22. Utility System Expansions

Site Plan

23A. Side stream centrate treatment, food waste/FOG receiving, thickening building expansion, future solids treatment processes
23B. Operations and Maintenance Building
23C. Parking Area/Digester Gas Utilization Equipment
23D. Advanced Water Treatment System
23E. Expanded Recycled Water Pumping
23F. CNG/RNG Station
23G. Lab

Figure 2-1 RP-5 Facility Layout

2.1.2 Flows and Loads

Based on the background of the project, the new solids treatment facility at RP-5 will be sized to process future solids production at RP-5 and CCWRF. The principal solids treatment processes will consist of thickening, digestion, dewatering, and digester gas treatment and use.

Projected plant influent flows at various IEUA's facilities through 2060 under various flow diversion scenarios were provided by IEUA (Volume III, Chapter 7, Appendix A).
The projected plant influent flows at RP-5 and CCWRF are summarized in Table 2-1.

Table 2-1: Plant Influent Flow at Average Condition, MGD

Year	RP-5	CCWRF
2016	9.3	7.4
2020	14.2	7.6
2025	16.0	7.6
2030	20.2	7.8
2035	22.8	7.9
2040	25.5	8.1
2045	27.6	8.2
2050	29.5	8.3
2060	30.0	8.5

Sludge production values were estimated on a per-million-gallon basis using the influent design pollutant concentrations selected on the RP-1 & RP-5 Expansion PDR Monthly Progress Meeting on March 7, 2016. These influent design concentrations were chosen after analysis of five years of the existing plant data with consensus among the design team and IEUA staff. The design concentrations chosen were based on maximum month values. If the 90th percentile concentration was greater than the max month value, then the 90th percentile value was used. The selected design concentrations are provided in Volume III, Chapter 7. Sludge production rates resulting from this analysis are summarized in Table 2-2.

Table 2-2: Sludge Production Rates at Max Month Condition, lb/MG

Parameter	RP-5	CCWRF
Max Month Primary Sludge	2,335	2,919
Max Month WAS	1,297	1,633
Max Month Total Sludge	3,632	4,552

[a] FOG and food waste are not included in these sludge quantity estimates

Sludge production fluctuates throughout the year as the plant influent flow and characteristics change. The solids handling facilities and associated equipment must be sized properly to be able to handle solids production during peak events. Therefore, several peaking factors are needed to design the solids handling systems, including maximum day, maximum week, maximum 2-week, and maximum month. However, there is not enough data available to determine all peaking factors to a high level of precision. Therefore, the peaking factors were determined by reviewing the available influent data as well as using the design team's engineering judgement, knowledge, and experience. Influent data were used to develop peaking factors because there was not enough available data on primary sludge and waste activated sludge (WAS) flow and solids percentages.

The peaking factors were developed for combined sludge as well as separate primary sludge and WAS. Peaking factors for combined sludge were used to size equipment after the two sludge streams are combined, such as combined thickening, digestion, and dewatering. Peaking factors for separate primary sludge and WAS production were used to size equipment for separate sludge thickening alternatives. The peaking factors for separate sludge streams are slightly higher than those of combined sludge because peak sludge production of primary sludge and WAS typically do not occur simultaneously. The peaking factors selected for this project are summarized in Table 2-3.

Table 2-3: Sludge Production Peaking Factors[a]

Parameter	Combined Sludge	Separate Sludge[b,c,d]
Max Month / Annual Average	1.40[a]	1.60
Max 2-Week / Max Month	1.68[b]	1.75
Max Week / Max Month	1.75[b]	1.90
Max Day / Max Month	1.82[a]	2.10

[a] Based on a review of existing plant data.

[b] Not enough existing data to determine this precise peaking factor – value based on the judgment and experience of the design team and interpolated from influent data (See Vol. II, Chapter 7)

[c] Peaking factors for separate sludge streams are higher than those of combined sludge because peak primary sludge and WAS productions typically do not occur simultaneously

[d] Peaking factors for PS and WAS are assumed to be the same

Solids flows and loads in the year 2060 were used for equipment and facility sizing and site planning. Solids flows and loads at the 2045 average annual condition were used for the BCE evaluations (Volume III, Chapter 7). Initial approved project construction will include equipment and facilities to process 2035 solids flows and loads, with some buildings sized and constructed now to accommodate future 2060 equipment.

Projected solids flow and loads at 2035 and 2060 are summarized in Table 2-4. Combined sludge flows and loads were used to size process equipment that treats combined sludge, such as combined thickening, digestion, and dewatering. Separate primary and WAS flows and loads were used to size process equipment that treat the two sludge streams separately, such as separate thickening and associated pumps and piping.

Table 2-4: Projected Sludge Productions in 2035 and 2060

Year		2035			2060		
Type of Sludge		**PS**	**WAS**	**Combined[a]**	**PS**	**WAS**	**Combined[a]**
TS (lb/day)	Average Annual	54,500	30,300	84,800	67,800	37,700	105,500
	Max Month	87,200	48,500	118,800	110,700	61,600	147,700
	Max 2 Week	95,400	53,100	142,500	121,100	67,400	177,200
	Max Week	103,500	57,600	148,500	131,500	73,200	184,600
	Max Day	114,400	63,700	154,400	145,300	80,900	191,900
VS (lb/day)	Average Annual	46,300	26,800	73,200	57,600	33,300	90,900
	Max Month	74,100	42,900	102,400	94,100	54,500	127,300
	Max 2 Week	81,100	46,900	122,900	102,900	59,600	152,800
	Max Week	88,000	51,000	128,000	111,800	64,700	159,100
	Max Day	97,300	56,300	133,100	123,500	71,500	165,500
Flow[b] (gal/day)	Average Annual	816,800	454,700	1,271,500	1,015,600	565,200	1,580,700
	Max Month	1,306,900	727,500	1,780,100	1,659,600	923,500	2,213,000
	Max 2 Week	1,429,400	795,700	2,136,200	1,815,200	1,010,100	2,655,600
	Max Week	1,552,000	863,900	2,225,200	1,970,800	1,096,700	2,766,300
	Max Day	1,715,300	954,900	2,314,200	2,178,300	1,212,200	2,876,900

a. Because peak production of primary sludge and WAS sludge occur at different times, combined peaking factors were developed for sludge production at peak conditions for combined sludge.

b. Based on raw sludge TS of 0.8%.

The thickening equipment and facilities were sized based on 2060 max day conditions shown in Table 2.1-4. The thickeners will be sized for either combined or separate primary sludge and WAS thickening. However, only thickening units required for combined thickening through 2035 will be constructed as part of the Approved Project. Based on the results of the BCE evaluations (Volume III, Chapter 7), IEUA staff has selected Rotary Drum Thickeners (RDTs) for sludge thickening. Thickened sludge flows and loads at different design conditions are summarized in Table 2-4.

The anaerobic digestion system was sized based on 2060 average annual and max 2-week conditions shown in Table 2-5. However, only digestion units required through 2035 will be constructed as part of the Approved Project.

Table 2-5: Digested Solids and Hydraulic Loading Projections

Performance Parameter		2035	2060
Solids Loading, ppd[b]	Average Annual	80,600	100,200
	Max 2-Week	135,400	168,300
VS Loading, ppd	Average Annual	69,500	86,400
	Max 2-Week	116,700	145,100
Hydraulic Loading, gpd[c]	Average Annual	193,300	240,300
	Max 2-Week	324,700	403,700
Sludge VS, % of TS		86	

a. based on thickening process solids capture rate of 95%

b. pounds per day

c. gallons per day

Digested sludge will be transferred to digested sludge storage tank prior to dewatering. During the workshop conducted on January 11, 2017, IEUA staff and the design team made the decision that all FOG and food waste will be directed to the RP-5 Solids Handling Facility (SHF) for digestion. Details of identifying quantities and qualities of FOG and food waste are discussed in Volume III, Chapter 8. The digestate from the SHF will be piped to RP-5 digested sludge storage tank for dewatering. The anticipated flows and loads for digested sludge and digestate from the SHF are summarized in Table 2-6. Theses flows and loads were used for storage tank and dewatering equipment and facility sizing. Figure 2-2 shows the process flow diagram.

Table 2-6: Digested Solids and Digestate Loading Projections

Performance Parameter			2035	2060
Digested Sludge	Solids Loading, ppd[b]	Average Annual	38,900	48,400
		Max Month	54,500	67,700
	Hydraulic Loading, gpd[c]	Average Annual	193,300	240,300
		Max Month	270,600	336,400
Digestate from SHF	Solids Loading, ppd[b]	Average Annual	19,800	22,500
		Max Month	19,800	22,500
	Hydraulic Loading, gpd[c]	Average Annual	82,000	93,000
		Max Month	82,000	93,000

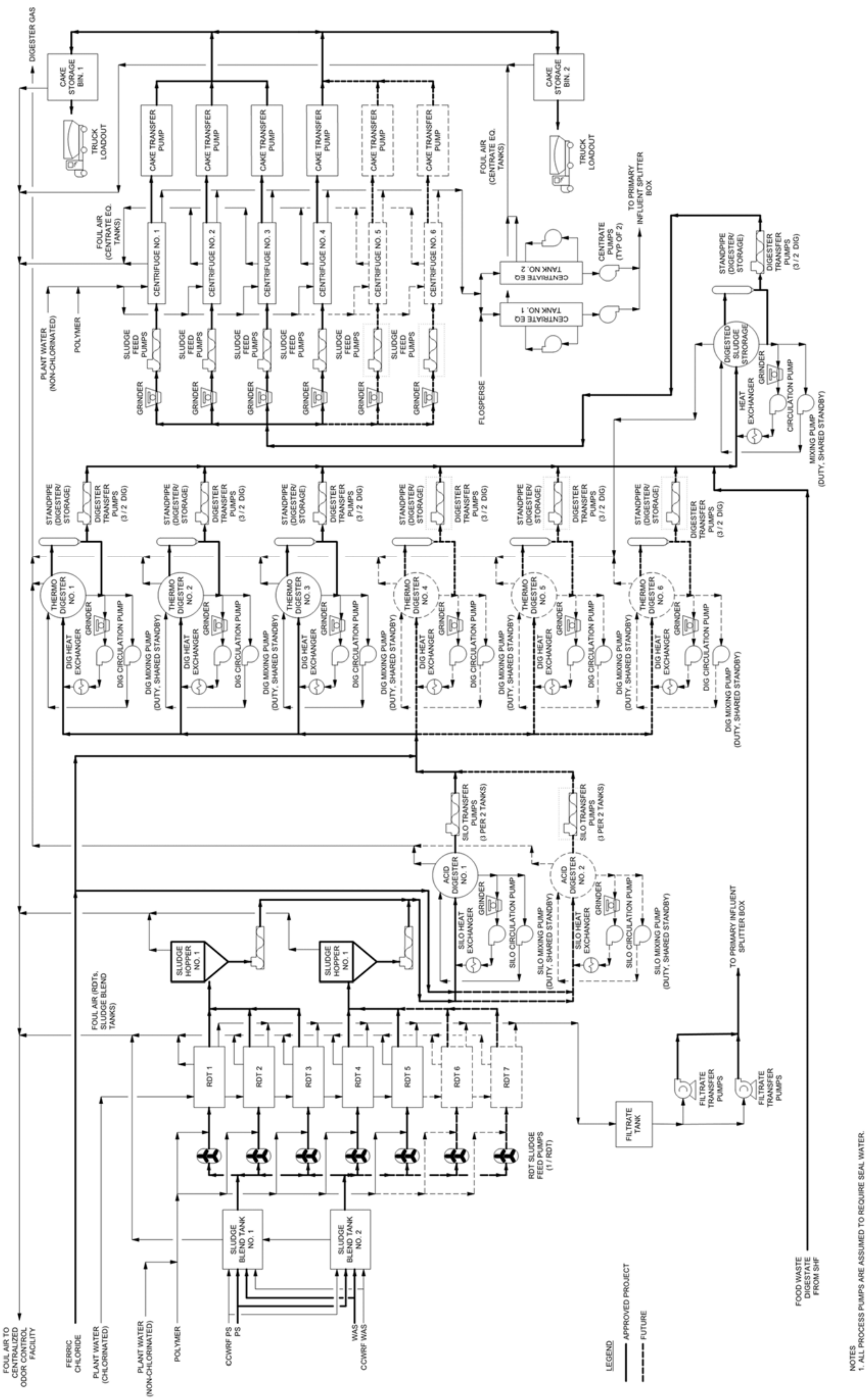


Figure 2-2: RP-5 Process Flow Diagram

2.2 THICKENING

2.2.1 Background

The new solids treatment facility at RP-5 will received sludge generated from the primary clarifiers (Primary Sludge) and from the secondary treatment process (WAS), from Carbon Canyon Water Recycling Plant, and RP-5. Thickening is used to increase the solids content of sludge and reduce its volume by removing a portion of water from the sludge feed. This reduction in volume increases the solids retention time in a subsequent digester, relative to digestion without thickening. Thickening, reduces the overall costs of sludge processing and handling.

Rotary drum thickeners (RDTs) were the selected technology for RP-5 solids thickening. Technologies screened during the selection process in Volume III, Chapter 7 included: gravity thickener; dissolved air flotation thickener (DAFT); centrifuge; membrane thickener; and gravity belt thickener (GBT). The selection of RDTs was based on the results from comparative analyses using criteria such as the effectiveness of the technology for both separate thickening and combined sludge co-thickening, agency direction during the August 11, 2016 workshop, and a BCE.

2.2.2 Description of Approved Thickening Technology

In rotary drum thickeners, the incoming sludge is mixed with polymer and flocculated to enhance particle separation before being introduced into a slowly rotating screen. Filtrate from the RDTs drains through the screen openings and collects in a trough underdrain. Thickened sludge is conveyed through the rotating drum and out the discharge end via a continuous internal screw or angled flights. The drum is sometimes inclined to aid in dewatering. An example of a single-drum style rotary drum thickener is shown in Figure 2-3.

Figure 2-3: Rotary Drum Thickener

(Photo courtesy of Parkson)

2.2.3 Thickening Schematic and Preliminary Facility Layout

The new solids treatment facility at RP-5 will receive primary sludge and waste activated sludge (WAS) generated at RP-5 and CCWRF. A new solids thickening building to house the RDTs will be constructed as part of the Approved Project. The separate primary sludge and WAS streams from each facility (RP-5 and CCWRF) will be blended into a homogenous mixed sludge to be co-thickened. Consideration and a design configuration will be provided to allow the system to thicken streams separately in the future.

The thickening building, concrete sludge storage tanks, polymer storage and aging tanks, and filtrate pump station will be sized for 2060 build-out conditions, while the sludge handling equipment and piping will be installed under the Approved Project to handle design maximum flows and loads projected for 2035, with one redundant unit. Two sludge tanks at the front of the thickening operation will serve as the blending tanks. Two thickened sludge hoppers will be installed at the tail end of the RDTs. Hard piped bypasses will be provided to be used in the event of an emergency or when units are down for maintenance.

The thickening facility will house a total of 7 RDTs at 2060 build-out. Phase 1 will consist of the installation of 5 RDTs, with 4 units on duty during max day flows. Each RDT will have a dedicated sludge feed pump and polymer feed pump. As such, five (5) sludge feed pumps and five (5) polymer feed pumps will be installed during Phase 1, with space being allocated for the future pumps in the pump room and polymer room. The polymer system will have one bulk storage tank, two (2) makeup units, and two (2) aging tanks to allow for one to be down for maintenance. The preliminary process schematic for the thickening facilities is shown in Figure 2-4 and the proposed preliminary layout for the RDT thickening facility is provided in Figure 2-5.

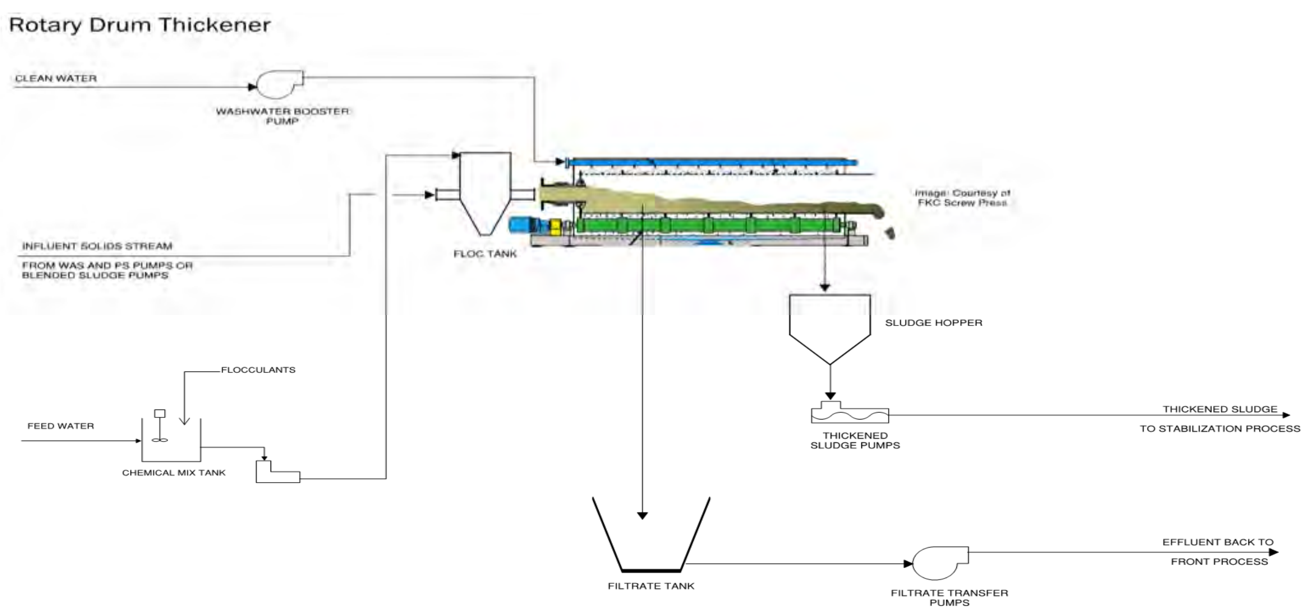


Figure 2-4: RDT for Sludge Thickening Facility Process Schematic

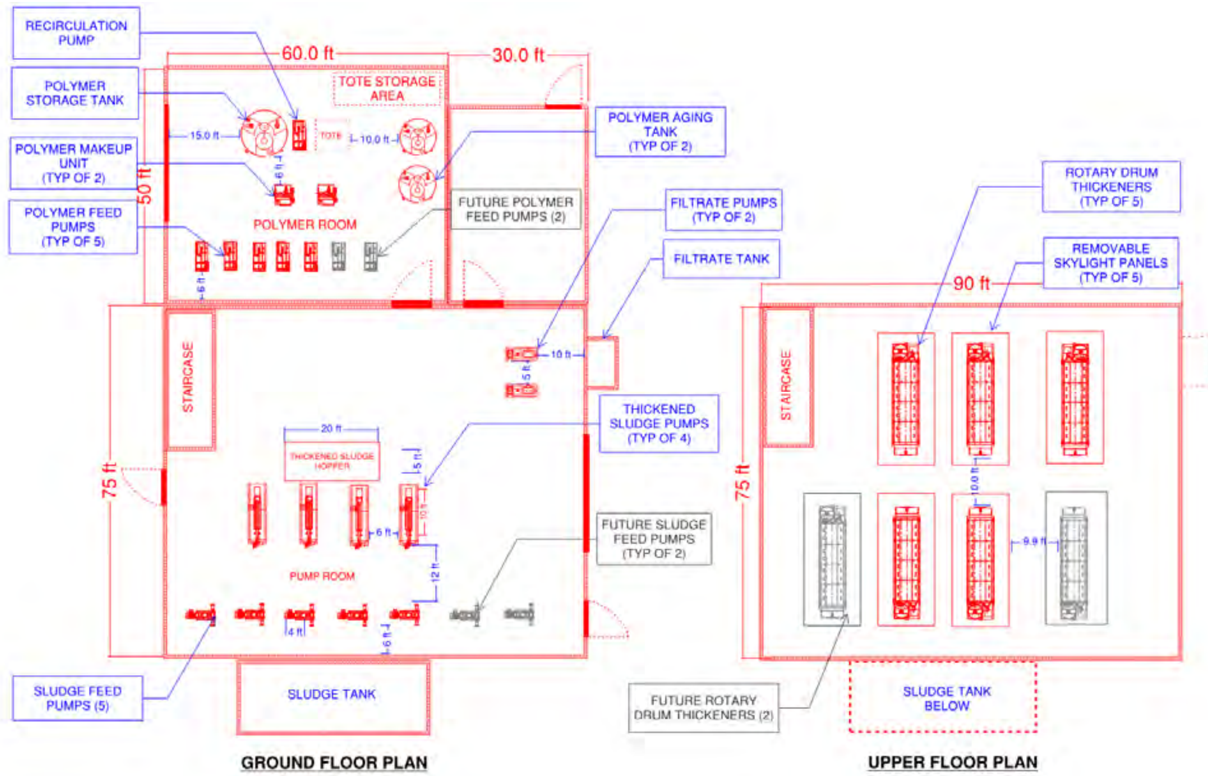


Figure 2-5: RDT for Sludge Thickening Facility Layout

2.2.4 Thickening Design Data

Projected maximum day and average annual flows and loads are summarized above in Table 2.1-4. The development and assumptions to produce flow and loads projections are presented in Chapter 2.1. Maximum day flows and loads were used to size the thickening facility to ensure facility is not hydraulically limited. If desired, during detail design, this assumption can be reassessed based on available equalization in upstream processes and to more closely match the digestion facility. Thickening operation is assumed to be continuous, 24 hours per day/ 7 days per week.

Rotary drum thickener performance goals shown in Table 2-7 were established for the purpose of evaluating the thickening technologies. These can be refined during detailed design based on IEUA objectives and related process selections.

Table 2-7: Thickening System Performance Goals

Performance Requirement	Value
Minimum thickened solids concentration	6% for 2-Phase Digestion
Minimum Solids Capture	95%

The RDT design criteria and sizing results are summarized in Table 2-8 and assume the “Basis of Design Manufacturer/ Model”. Mechanical equipment installed during Phase 1 will be sized for enough capacity to handle 2035 maximum day flows and loads. One redundant unit will be available during max day flows and loads. Bypasses will be provided to manage flows in the event of an emergency.

Table 2-8: RDT Design Criteria

Design Parameter	Unit	Primary Sludge	WAS	Combined Sludge
2035 Max. Day hydraulic Loading Rate	gpm	1,200	665	1,605
Unit Hydraulic Loading Rate, max	gpm/unit	400	400	400
Polymer Dosage	lb/dry ton	5	10	8
Wash Water Requirement	gpm	50	50	50
Energy Consumption	hp	10	10	10
Basis of Design Manufacturer/ Model		Parkson RDT-400	Parkson RDT-400	Parkson RDT-400
Drum Diameter	in	44	44	44

Design criteria and preliminary sizing results for the thickening facility tanks are presented in Table 2-9. Raw sludge tanks, thickened sludge hoppers, and filtrate tank, being potentially concrete structures, will be sized for 2060 maximum day flows. The raw sludge and thickened sludge tanks will be designed for a minimum 20-minute detention time, affording the raw sludge feed pumps and thickened sludge pumps to operate without abrupt hydraulic changes.

Depending on final project elevations it could be determined that sufficient differential is available to gravity drain to filtrate to the front of the plant. However, for planning purposes it is assumed that the filtrate will need to be pumped and a filtrate pumping station is required. The filtrate tank will not be sized to provide hydraulic detention as the pumps will operate in fill and draw.

Table 2-9: Thickening Facility Tankage Design Data

Design Criteria	Unit	Value
Sludge Tanks		
2060 Max. Day Hydraulic Loading Rate	gpm	2,000
Hydraulic Detention Time	min	20
Number of Tanks		2
Tank Dimensions		
Height	ft	10
Width	ft	15
Length	ft	40
Thickened Sludge Hopper		
Hydraulic Loading Rate	gpm	304
Hydraulic Detention Time	min	20
Number of Hoppers		2
Hopper Dimensions		
Height	ft	10
Width	ft	5
Length	ft	20
Filtrate Tank		
Hydraulic Loading Rate	gpm	1,700
Hydraulic Detention Time	min	N/A

Design Criteria	Unit	Value
Number of Tanks		1
Tank Dimensions		
Height	ft	10
Width	ft	5
Length	ft	10

The pumping systems and conveyance will be designed to account and accommodate a wide range of thickening equipment performance (i.e. higher %TS of thickened sludge). Phase 1 sludge handling equipment will be sized to handle the 2035 maximum day flows and loads. The filtrate system will be sized to handle 2035 maximum day flows and load plus one redundant unit. Piping systems will be lined to prevent build-up of grease and to allow pumping of high viscosity sludge. Table 2-10 shows the preliminary sizing results for the thickening facility's pumping systems.

Table 2-10: Pumping Systems Design Data

Design Criteria	Unit	Value
Sludge Feed Pumps		
2035 Max. Day Hydraulic Loading Rate	gpm	1,605
Capacity	gpm	400
Pressure	psi	15
Number of pumps		5
Motor size	hp	30
Thickened Sludge Pumps		
Hydraulic Loading Rate	gpm	250
Capacity	gpm	100
Pressure	psi	15
Number of pumps		4
Motor size	hp	30
Filtrate Pumps		
Hydraulic Loading Rate	gpm	1,400
Capacity	gpm	2000
Pressure	ft	30
Number of pumps (duty / standby)		1 / 1
Motor size	hp	20

The emulsion polymer system will be sized for 10 lb/ton, which is the maximum polymer dosage requirement expected for the RDT system operation. Preliminary sizing results for Phase 1, based on 2035 maximum daily solids loading is presented in Table 2-11. One polymer feed pump will be provided per RDT. For Phase 1 no redundant unit is assumed.

The polymer system and other ancillary systems such as wash/spray water and electrical will be designed to allow for operation of all thickening units simultaneously in order to provide maximum operational flexibility.

Table 2-11: Emulsion Polymer System Design Data

Design Criteria	Unit	Value
2035 Max. Day Solids Loading	lb/hr	154,400
Polymer Dosage	lb/ton	10
Neat Polymer Storage Tank		
Number of Storage Tanks		1
Capacity	gal	
Recirculation Pump		
Capacity	gpm	100
Motor size	hp	7.5
Make-up Unit		
Capacity	gph	40
Electrical requirement	hp	1
Aging Tanks		
Number of Aging Tanks		2
Detention Time	min	30
Capacity	gal	4,000
Polymer Feed Pumps		
Capacity	gpm	5
Pressure	psi	50
Number of pumps		5
Motor size	hp	3

2.2.5 Thickening Odor Control

Rotary drum thickeners will be fully enclosed and provided with foul air take-off connections to tie into the odor scrubber system to reduce odors from this area. Point source control of odors greatly reduces the amount of foul air and ultimately the size of the odor treatment system. Sludge storage tanks and filtrate tanks will also be ventilated to reduce the potential for odor and corrosion. Table 2-12 show the preliminary odor control design criteria for the thickening facility. The foul air extracted from the thickening building processes will be conveyed to a centralized plant-wide odor treatment facility.

Table 2-12: Odor Control Design Data

Source	Design Criteria	Air Flow Rate per unit	Total Air Flow
		cfm	cfm
RDT	Parkson-400	430	3000
Sludge Blend Tanks	Leakage Rate, 0.5 cfm/sq. ft.	300	300
Thickened Sludge Tanks	Leakage Rate, 0.5 cfm/sq. ft.	50	50
Filtrate Tanks	Leakage Rate, 0.5 cfm/sq. ft.	50	50

2.3 ANAEROBIC DIGESTION AND HOT WATER SYSTEM

2.3.1 Background

The new anaerobic digestion facility at RP-5 will receive solids generated from the RDT thickening facility to stabilize and reduce the mass solids through an anaerobic digestion treatment process. Two-phase anaerobic digestion (2-phase acid/gas) with thermophilic temperatures in gas phase digestion was the selected technology for RP-5 solids digestion. Technologies screened during the selection process described in Volume III, Chapter 7 included: mesophilic anaerobic digestion (MAD); 2-phase acid/gas phase digestion; and thermal hydrolysis process (THP). The selection of 2-phase acid/gas digestion was based on favorable historical experience by IEUA, projected improved biogas production and increased digestion efficiency, BCE evaluation results, and recommendations developed during the August 11, 2016 Workshop and October 2016 Board Workshop.

Digester gas generated by the digesters will be used for gas utilization equipment, specifically cogeneration (REEP facility), and/or the plant's central heating facility boilers. Digester gas will preferentially be directed to the REEP facility for cogeneration to produce electricity and hot water. Hot water generated at the REEP will be used to meet digester and building heating demands at RP-5, but the quantity of heat may not always be adequate to meet these needs. A central heating facility housing new boilers will be provided and will use natural gas, or digester gas if available, to provide additional heat for the digestion process. Digester gas that cannot be used by either of these end uses would be disposed of in waste gas flares.

2.3.2 Description of Approved Anaerobic Digestion and Boiler Technology

Acid/gas (2-phase) digestion is a two-stage anaerobic digestion process comprising separate acid and gas phase anaerobic digesters. Acid-phase digestion is the first digestion phase, and is operated with a short solids retention time (SRT) of 1-2 days, during which the substrates are hydrolyzed to produce volatile fatty acids (VFAs). In the second digestion phase, methanogen bacteria are grown on these VFA's which require a longer SRT (greater than 5 days) and are thus excluded from this acid-phase digester (aka acid silo). The recommended total SRT for optimum digestion of 15 days will be met with the acid-phase and gas-phase digesters operated in series. Although the second digestion phase can be operated at either thermophilic or mesophilic temperatures, the intended operation will be thermophilic (typically, 131 degrees Fahrenheit). This separation in phases has been demonstrated through long term operation by IEUA to improve solids reduction and increase gas production. A PFD for 2-Phase digestion process is provided in Figure 2-6. It should be noted that IEUA is interested in exploring two stages of gas phase digestion in series, potentially thermophilic followed by mesophilic. That process configuration would require larger pipes and pumps between stages and will be evaluated in detailed design.

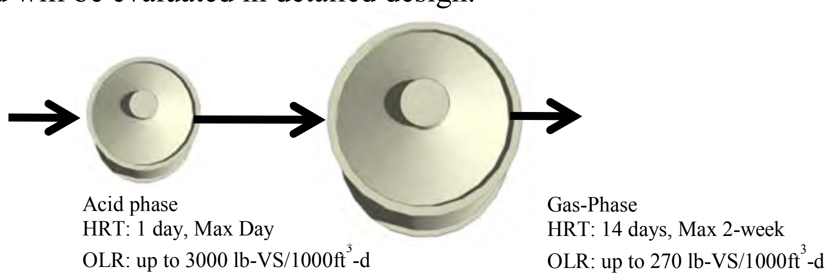


Figure 2-6: Phase Digestion Process Schematic

The boilers for the new central heating facility would include three hot water boilers. Flexible water-tube boilers (Figure 2-7) are recommended for this application because the flexible tubes are tolerant of thermal cycling and other WWTPs have reported less siloxane buildup with them compared to fire-tube boilers.

Figure 2-7: Water-Tube Boiler

Photos courtesy of Bryan Steam LLC

2.3.3 Anaerobic Digestion and Central Heating Schematic and Preliminary Facility Layout

Process schematics and conceptual facility layouts for the two-phase digestion system are provided in Figures 2-8 through 2-10.

The new anaerobic digestion facility will receive thickened primary and waste activated sludge discharged from the new solids thickening facility RDT's. FOG and food wastes will be treated separately at the existing RP-5 SHF digestion facility. The resulting FOG and food waste digestate will be pumped to the digested sludge storage tank downstream of the new anaerobic digesters in preparation for dewatering at the new solids dewatering facility (refer to section 2.5).

One new acid phase digester and three new thermophilic gas phase digesters and one sludge storage tank, configured to be capable of operating as a backup gas phase digester, will be constructed as part of the year 2035 Approved Project (Phase 1). A second acid phase digester and a fourth and fifth thermophilic gas phase digesters are planned to be installed in the future for the 2060 build-out requirements. Under Phase 1 and buildout, all gas phase digesters will be equipped identically to function as thermophilic anaerobic digesters even though up to two digesters can serve also as digested sludge holding tanks.

As stated above, IEUA is interested in exploring two stages of gas phase digestion in series, potentially thermophilic followed by mesophilic. That process configuration would require larger pipes and pumps between stages and will be evaluated in detailed design.

The acid phase digestion facility will be configured to house a total of two acid digesters at 2060 build-out. Phase 1 will consist of the installation of one acid phase digester with two feed control valves, two heat exchangers, two grinders and circulation pumps, two sludge mixing pumps and sludge transfer pumps. One of the sludge HEX, mixing and transfer pumps will be provided as standby; in the future the standby equipment will serve the second acid digester. An electrical room will be sized for buildout conditions but equipped for the Phase 1 power requirements.

The gas phase digestion facility will house a total of five gas phase digesters and one storage tank at 2060 build-out. Phase 1 will consist of the installation of three gas phase tanks each with a dedicated feed control valve, heat exchanger, grinder and circulation pump, a sludge mixing pump and sludge transfer pump. Shared standby sludge mixing and transfer pumps will be provided between each pair of gas phase digesters.

The equipment gallery and electrical room will be sized for the three Phase 1 gas phase digesters and one storage tank. The buildout condition will be accommodated with a future building expansion.

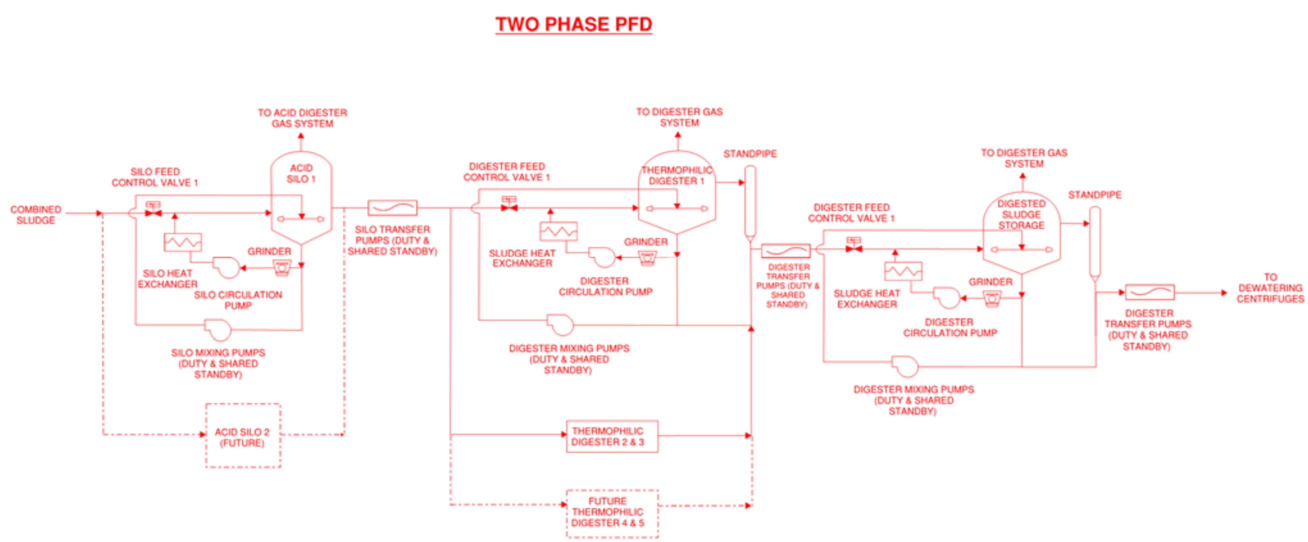


Figure 2-8: Two-Phase Anaerobic Digestion PFD

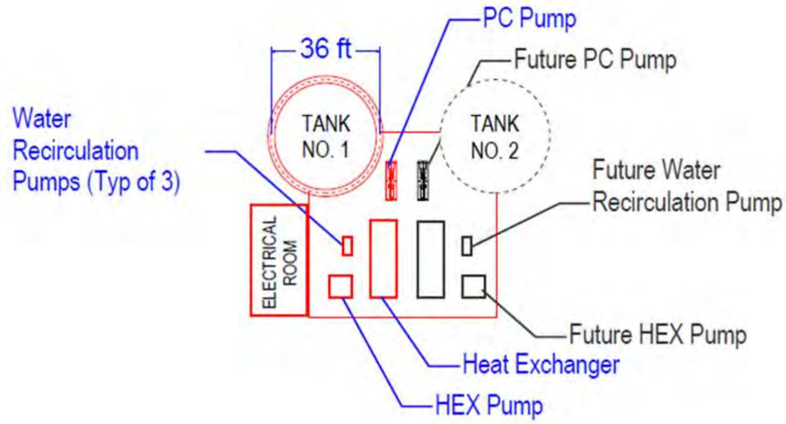


Figure 2-9: Acid Reactor Layout

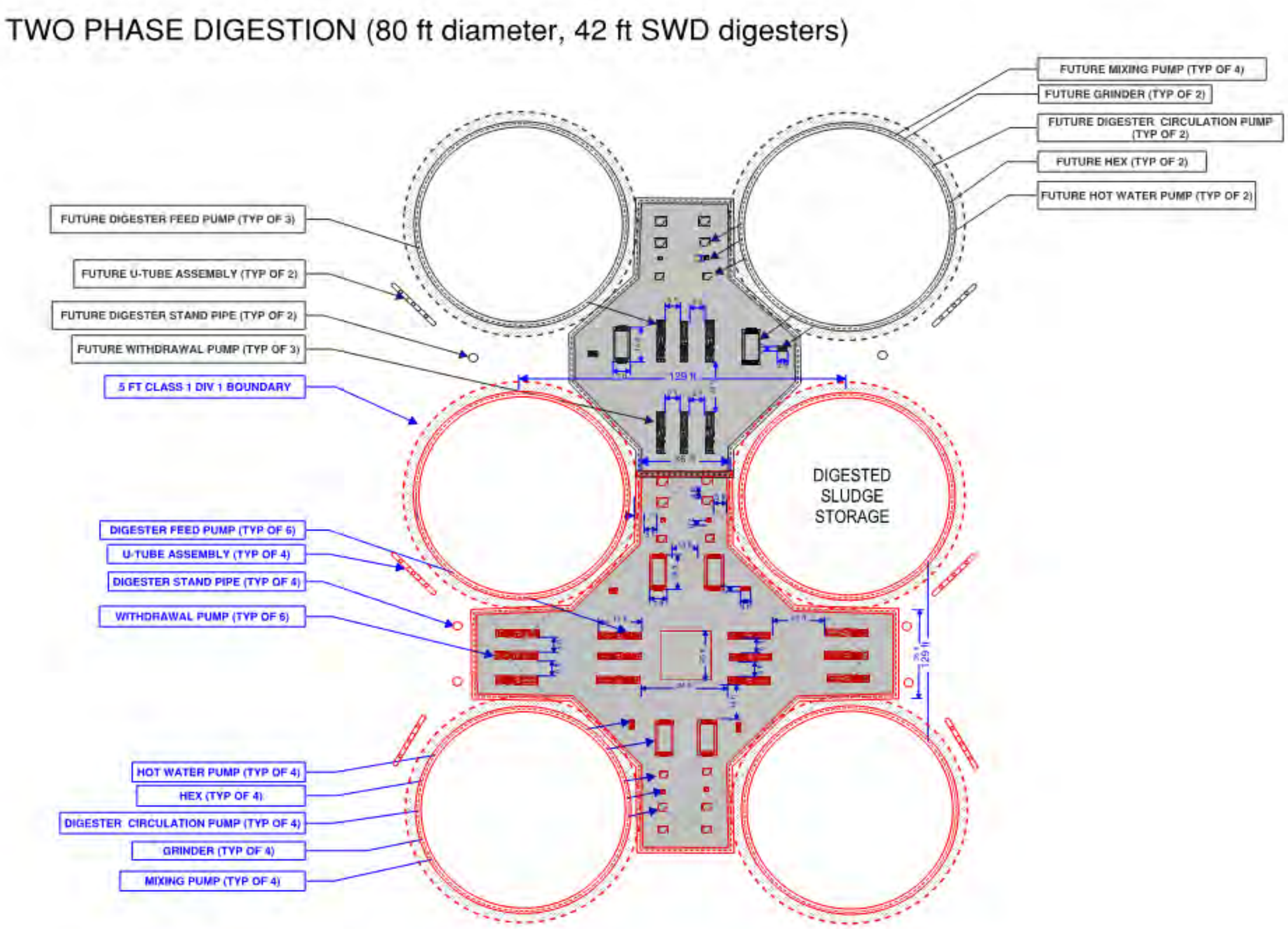


Figure 2-10: Thermophilic Digesters Layout

The central heating facility will be located just west of the dewatering facility and will occupy about 3,000 sqft. The building will house the two duty and one standby boilers, hydronic pumps, and related electrical and HVAC equipment (Figure 2-11).

The boilers shown are of adequate size to meet 2035 heat demands. Adequate floor space and ventilation in the boiler room would be included to permit larger boilers to replace the proposed boilers in the future, if necessary, to meet future heat demands. Overhead doors would provide access to the boilers for maintenance. The boilers could be installed and removed through the overhead doors via a forklift.

The hydronic pumping system includes two variable-speed duty/standby main heat loop pumps for circulating hot water for digester and building heat, as well as an expansion tank and air separator. One side-loop pump and 3-way valve for each boiler would be provided for circulating hot water from and to the main heat loop through the boilers.

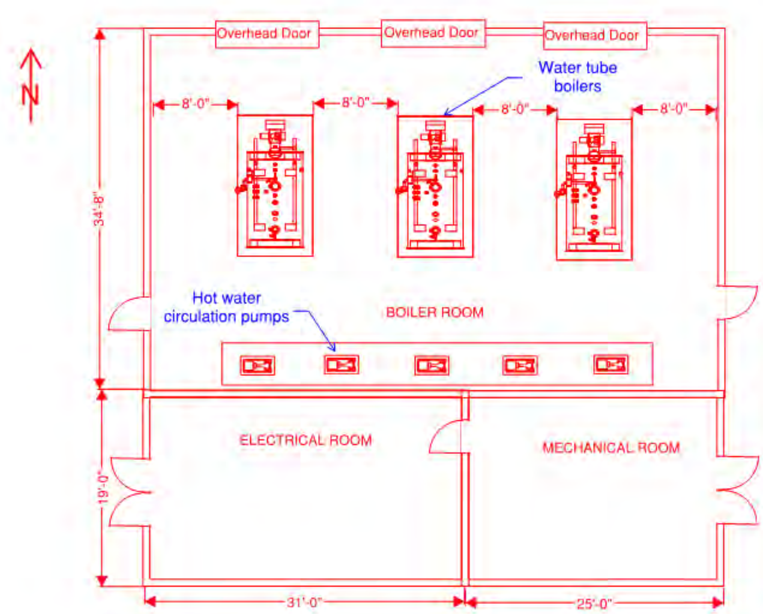


Figure 2-11: New Central Heating Facility Layout

2.3.4 Anaerobic Digestion and Boiler Design Data

Projections for the solids flows and loads to the digestion facility following solids thickening for both the maximum day and maximum 2-week conditions have been developed and are presented above.

Digester sizing and site layout is based on year 2060 (build-out). Max 2-week flows and loads were used to size digestion facility total 15-day SRT and acid reactors were sized for max day. Redundancy is provided with standby pump and HEX, recirculation pump for mixing, and a digested sludge storage tank to operate as a standby anaerobic digester. In the event the acid tank needs to be taken off line, operators will convert to straight single stage digestion. If a digester is off line during a high load period, operations can elect to operate at shorter than 15-day SRT or utilize the storage tank for digestion and operate dewatering for longer periods. Digested sludge and received digestate from digested FOG/food waste will be blended in the storage tank prior to transfer to dewatering. Digester performance and sizing data is provided in Table 2-13 and digester tank design data is provided in Table 2-14.

Table 2-13: Two-Phase Digestion Performance and Sizing Data

Design Condition	2025	2035	2060
Digester Tank Volume and Number			
Acid Tank Volume, mgal		0.35	
Acid Feed Tank Number	1	1	2
Digester Volume, mgal		1.52	
Digester Tank Number	3	3	5
Acid Digester SRT, day			
Max Day, all in service	1.3	1.0	1.6
Gas Digester SRT, day			
Max 2-week, all in service	17.9	14.0	19.0
Acid Digester VS Loading, lb/cuft			
Max Day, all in service	2.1	2.7	1.7
Gas Digester VS Loading, lb/cuft			
Max 2-week, all in service	0.15	0.19	0.14

a. At one tank out of service.

Table 2-14: Two-Phase Digestion Design Data

Design Criteria	Unit	Value
Acid Phase Digester		
Diameter	ft	36
Height[a]	ft	50
SWD	ft	46
Gas Phase Digester		
Diameter	ft	80
Height[b]	ft	50
SWD	ft	40

a. Includes 4 ft freeboard.

b. Includes 3 ft freeboard and 15% volume expansion.

The solids feed characteristics that will impact digestion are summarized in Table 2-15.

Table 2-15: Projected Digestion Feed Characteristics

Sludge Characteristic	Average Value
Nominal Sludge Composition, Total Dry Solids Weight Basis	Blend of primary sludge and waste activated sludge
Total solids concentration, %TS	5
Volatile solids (VS), % dry mass basis	86
Temperature, deg F	65 - 85
Average pH	7

a. After pre-dewatering facility

The preliminary selection for the boilers was based on 2035 projected peak 14-day digester and building heating demands, and area emissions requirements. The design requirements for the boilers are presented in Table 2-16. The design includes 3 steel flexible water tube type boilers, each with capacities of 175 boiler horsepower (5.9 MMBtuh). This provides slightly more boiler capacity than required, but any standard boiler size smaller than 175 boiler horsepower would not provide adequate heating capacity.

Table 2-16: Boiler Design Criteria

Parameter	Unit	Value
Total heat demand (peak 14-day, 2035)	MMBtuh	11.1
Digester heat demand	MMBtuh	8.7
Building heat demand	MMBtuh	2.4
Fuel input gas input (peak 14-day, 2035)	MMBtuh	13.9
Fuel type	--	Natural gas / conditioned digester gas[a]
Number of Boilers	Duty / Standby	2 / 1
Maximum hot water output, each	MMBtuh	5.9
Minimum hot water output, each	MMBtuh	1.5
Water temperature	Deg F	180 - 200
Boiler NOx emissions[b], natural gas / digester gas	ppm	12 / 15
Required fuel pressure (natural gas and digester gas)	psig	5
Boiler type	--	Flexible steel water tube
Boiler Basis of Design Model	--	Bryan RW850-W (hot water)

a. Conditioned digester gas is assumed to be provided at a pressure of 5 psig, have a minimum energy content of 550 Btu/scf, less than 40 ppm H_2S, dew point of 40 deg F, and less than 0.5 mg Si / Nm^3.

b. South Coast Air Quality Management District boiler emissions requirement.

2.4 STRUVITE CONTROL SYSTEMS

2.4.1 Background

Struvite is a magnesium ammonium phosphate mineral (Mg NH4PO4 +6H2O) with the characteristics of a white crystalline solid. Under the digestion process, ammonia and phosphorus are released and if sufficient magnesium is present, struvite may form in the anaerobic digester tanks, digested sludge piping, and downstream dewatering equipment and centrate piping. Struvite also forms under turbulent conditions where carbon dioxide is released. Once formed struvite may coat the interior surfaces of tanks, piping and dewatering equipment which reduces efficiencies, and can be difficult and costly to remove. Ferric Chloride (FeCl3) has been shown to be effective in struvite control by binding phosphorous (PO4) to form Iron Phosphate (FePO4). Ferric Chloride has also been demonstrated to reduce hydrogen sulfide concentrations in digesters.

2.4.2 Description of Approved Struvite Control System

IEUA stores a 38 percent solution of ferric chloride at the primary chemical facility in a single fiberglass reinforced concrete containment area. To precipitate phosphorus and inhibit struvite from forming, a 38 percent ferric chloride solution will be metered into an injection point prior to either or both the acid and gas phase digesters. A day tank and metering pump will be provided for ferric chloride injection at the 2-phase digestion facilities.

2.4.3 Design Criteria

The ferric chloride dosing facilities at the 2-phase digestion process will be sized for both ortho-phosphorous and sulfur removal. Although ortho-phosphorous is the primary target, the presence of hydrogen sulfide will compete for ferric chloride and result in additional ferric chloride demand. Preliminary sizing will assume up to 500 mg/l hydrogen sulfide removal and up to 100 mg/l orthophosphate removal. The preliminary equipment sizing at a 1.5 peaking factor above average annual is provided in Table 2-17. The preliminary day tank size for the Year 2035 deign condition is 3500 gallons which can provide 10 days' storage at Year 2025 and 6 days' storage at Year 2060. The initial ferric chloride day tank sizing was conservative to account for infrequent ferric deliveries to the plant and anticipated dosing rates related to struvite and H_2S control. It is likely smaller sized ferric day tanks may be applied for this application, but further evaluation is required. In addition, ferric chloride dosing rates and metering facilities will be confirmed during detailed design, as both will impact day tank sizing.

Table 2-17: Ferric Chloride Day Tank and Metering Sizing Design Data

Performance Parameter	2025	2035	2060
Average Annual Solids Loading, ppd (RP-5 and CCWRF)	66,200	98,300	105,500
FeCl3 flow rate, gph	15	23	24
FeCl3 Day Tank size at 7-day storage, gal	2500	3800	4100
Metering pump size, gph	32		
Day Tank Size, gal	3500		

2.5 DEWATERING, CAKE TRANSFER, STORAGE, AND LOADOUT

2.5.1 Background

The new solids dewatering treatment facility at RP-5 will received digested solids generated from 2-phase anaerobic digestion and digestate received from the FOG and food waste digestion at the SHF facility. Dewatering is the final stage of solids treatment prior to disposal of solids.

Centrifuges are the preliminary selected technology for RP-5 solids dewatering. Technologies screened during the selection process included: centrifuge; belt filter press (BFP); and screw press (Volume III, Chapter 7). The selection of centrifuge dewatering was based on results from screening evaluations, high cake solids and solids capture, low daily maintenance, low equipment repair, minimal odor, IEUA familiarity with equipment, and discussion during the August 11, 2016 Workshop and October 2016 Board Workshop.

2.5.2 Description of Approved Dewatering Technology

A centrifuge is composed of two concentric cylinders, rotating at slightly different speeds. In the outer cylinder, centrifugal force propels the heavier digested solids to the wall of the outer cylinder at accelerations of approximately 3,000 gravitational units (Gs). Centrate, the remaining residual liquid, accumulates along the axis of rotation and is discharged over a concentric weir. The inner cylinder has a scroll encircling its outer surface. Because the inner cylinder rotates at a slightly slower rotational speed than the outer cylinder (the differential), the scroll moves along the inner surface of the outer cylinder, conveying the dewatered solids to a dewatering beach, and then to its discharge. The liquid centrate is conveyed via an overflow weir to a liquid drain. A picture of a dewatering centrifuge is presented in Figure 2-12.

Figure 2-12: Dewatering Centrifuge

Image courtesy of Alfa Laval

2.5.3 Dewatering Schematic and Preliminary Facility Layout

A schematic of the dewatering facility is shown in Figures 2-13 and 2-14. Four centrifuges will be provided for 2035. No redundant unit is provided. In an emergency, if a unit is off line during a high load period, operations can elect to increase centrifuge loading rates, continue to store until back on line or an extended operating period can be used up to 24-hour per day operation. - Supporting systems such as polymer, feed pumping, cake pumping and electrical will be designed to allow for operation of all dewatering units to operate simultaneously.

Three days of upstream digested sludge storage is provided to eliminate the need for dewatering shifts during three day weekends and also to provide additional operational flexibility for the dewatering system. To provide additional flexibility in operation, the digested sludge storage tank was sized to match the gas phase digesters. At this size, the tank will provide over three days of sludge storage and can serve as a backup digester if desired.

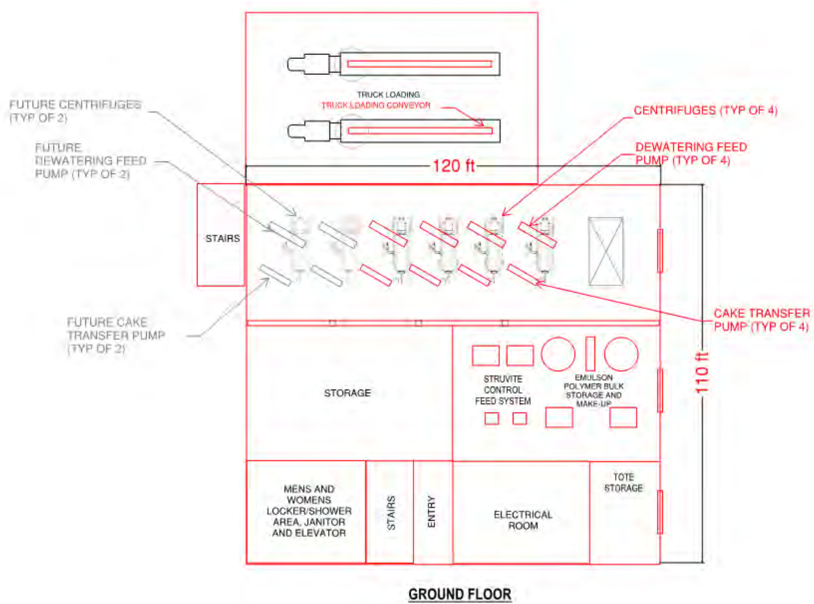


Figure 2-13: Dewatering Centrifuge Ground Floor Layout

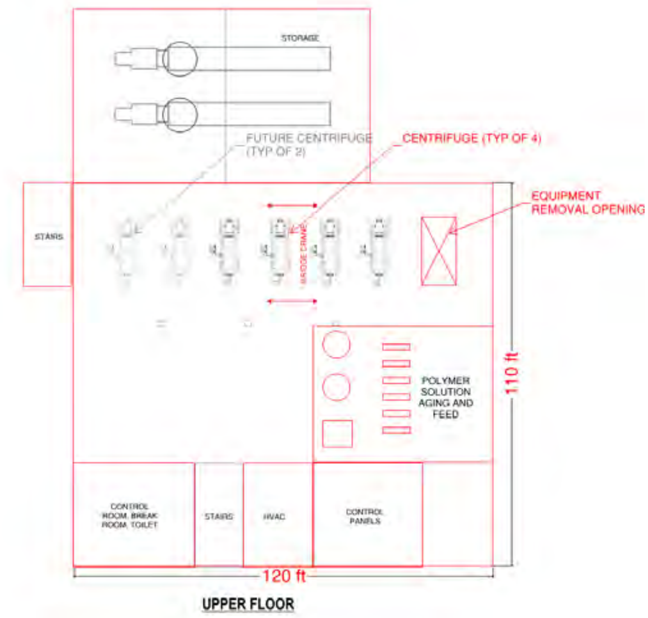


Figure 2-14: Dewatering Centrifuge Upper Floor Layout

Results for centrifuge sizing are presented in Table 2-18 based on IEUA's preliminary selection of this dewatering technology.

Table 2-18: Dewatering Centrifuge Equipment Number of Operating (Duty) Units

Parameter	2025	2035	2060
Maximum month loading	3.1	3.9	4.7
Average annual loading	2.5	3.0	3.7

Digested sludge storage tank mixing will be provided to keep solids in suspension and digested sludge storage will be connected to the low pressure digester gas management system. Minimum total digested sludge storage requirements are shown in Table 2-19 to provide 3 days of storage. As previously described, the digested sludge storage tank was sized to match the gas phase digesters. At this size, the tank will provide over three days of sludge storage and can serve as a backup digester if desired.

Table 2-19: Digested Sludge Minimum Storage Requirement (3 days' storage)

Loading Condition	2025	2035	2060
Maximum month	901	1,101	1,344
Average annual	711	857	1,039

a. Storage requirements are shown in 1,000 gallons.

2.5.4 Dewatering Design Data

Projections for the solids flows and loads from anaerobic digestion to dewatering for both the maximum month and annual average conditions have been developed and are presented above.

The solids feed characteristics from anaerobic digestion that may impact dewaterability are summarized in Table 2-19.

Table 2-20: Projected Dewatering Feed Characteristics

Sludge Characteristics	Value
Nominal Sludge Composition, Total Dry Solids Weight Basis	Anaerobically digested blend of primary sludge, waste activated sludge, food waste and FOG
Total solids concentration, %TS	2.5
Volatile solids (VS), % dry mass basis	72
Temperature, deg F	85-100
Average pH	7

These design performance requirements (Table 2-21) will be refined based upon IEUA objectives and related process selections during detailed design. Maximum month digested sludge was selected for the design basis with the understanding that 3 days of upstream digested sludge storage will be provided, the operating schedule may be extended slightly during peak digested sludge production and a full standby unit will be provided.

Table 2-21: Dewatering System Performance Requirements

Performance Requirement	Value
Dewatering system solids processing capacity[a], dry lb TS/hour	13,500
Dewatering system hydraulic processing capacity[a], gpm	1,070
Minimum cake solids, % TS	24
Minimum solids capture efficiency, %	95

a. Based upon maximum month projection for 2035 and 8 hours/day, 5 day/week operating schedule.

Design criteria for the centrifuges and sizing results are summarized in Table 2-22. The design criteria for centrifuges are based on the "Basis of Design Manufacturer/ Model". Sizing for Phase 1 will be based on capacity to dewater the 2035 maximum month digested sludge production plus one standby unit. Initial sizing of the dewatering centrifuges assumed a capacity of 3,500 gpm. It is anticipated that greater capacities, up to possibly 4,000 gpm may be possible. The difference in centrifuge capacity does not impact the number of units required; therefore, this evaluation assumes 3,500 gpm. Further investigation into centrifuge capacity is recommended during detailed design. Ancillary equipment design data is provided in Table 2-23.

Table 2-22: Centrifuge Design Criteria

Design Parameter	Unit	Value
Number of Units		3+1
Unit Solids Loading Rate Capacity	lb/hr	4,000
Unit Hydraulic Loading Rate Capacity	gpm	300
Polymer Dosage	lb APS/dry ton	35
Connected Horsepower	hp	250
Basis of Design Manufacturer/ Model		Andritz D7LL
Bowl Diameter	in	30

Table 2-23: Ancillary Equipment Design Criteria

Design Parameter	Unit	Value
Dewatering Feed Pumps		
Number of Units		3+1
Capacity	gpm	300
Cake Pumps		
Number of Units		3+1
Capacity	lb/hr	4,000
Emulsion Polymer Bulk Storage		
Number of Units		2
Total Storage Provided	gallons	16,000
Polymer Make-Up Units		
Number of Units		1+1
Capacity	gpm	TBD
Polymer Solution Feed Pumps		
Number of Units		3+1
Capacity	gpm	70
Cake Storage Bins		
Number of Units		2
Total Storage Provided	cubic yards	425
Truck Loading Conveyors		
Number of Units		2
Capacity	wet tons/hr	250

2.5.5 Struvite Management

Current practices at RP-1 includes dosing of FlowSperse to control formation of struvite in the dewatering centrate lines. FlowSperse is a liquid dispersant design to reduce the potential for struvite accumulation in centrate piping downstream of the dewatering equipment. The dewatering facility will allow provisions for the storage and dosing of FlowSperse into the centrate system downstream of dewatering. It is intended that this practice will protect the centrate lines and centrate equalization system downstream of the dewatering from struvite accumulation.

2.5.6 Dewatering Odor Control

Dewatering centrifuges are totally enclosed and equipped with foul air take-off connections on the unit housings, centrate chutes and the solids chutes. Additionally, it is recommended that foul air connections be provided on all of the conveyors used to move solids between processes as they can be a significant odor source. Point source control of odors greatly reduces the quantity of foul air and ultimately the size of the odor control system. Sludge storage tanks and filtrate tanks will also be ventilated to reduce the potential for odor and corrosion. The foul air extracted from processes in the dewatering building will be conveyed to the centralized odor control facility. Odor control design criteria are presented in Table 2-24.

Table 2-24: Odor Control Design Criteria

Location	Source	Design Criteria	Air Flow Rate per unit	Total Air Flow
			cfm	cfm
Dewatering Building	Centrifuge	Per manufacturer	400	1000
	Conveyors	5 cfm/lf	200	1000
	Cake Bins	Leakage Rate, 1 cfm/sq. ft.	500	1000
	Truck Load Out Room	12 ACH	8500 (per bay)	17,000
	Centrate Storage Tanks	Leakage Rate, 1 cfm/sq. ft.	1000	2000

2.6 CENTRATE EQUALIZATION & RETURN TO PRIMARY INFLUENT SPLITTER BOX

2.6.1 Background

Centrate from the dewatering treatment facility at RP-5 will received digested solids generated from 2-Phase anaerobic digestion, dewatering is the final stage prior to disposal of solids. Returning Centrate flows to RP-5 liquids process was the selected treatment alternative. Technologies screened during the selection process included disposal in an existing brine pipeline, side stream nitrogen removal, and side stream phosphorus removal (Predesign Report Volume II, Chapter 2). Returning Centrate flows to the RP-5 liquid process was the simplest alternative requiring only equalization tanks, minimal mechanical equipment, and odor control (supplied by a centrally located system). The selection of liquid stream treatment was based on results from screening evaluations, a BCE, IEUA familiarity of equipment, and recommendations during Workshops.

2.6.2 Description of Approved Centrate Equalization

Centrate is a nutrient rich residual stream produced by dewatering digestate. The stream is recycled to the head of the liquid stream treatment train and can represent 15-25% of the total nutrient load. Often requiring an increase in aeration basin volume and aeration demands to meet treatment limits for the additional load. Ammonia in Centrate can cause fluctuations in effluent pH and alkalinity, especially if Centrate is returned over a short duration of time. If total nitrogen removal is required Centrate can also represent a significant chemical demand for carbon limited facilities which require additional carbon sources (typically methanol) to balance the nutrient load. To prevent a short Centrate return duration an equalization tank is recommended to evenly distribute the Centrate over a 24-hour period. Centrate can also be returned to the liquid stream in a diurnal pattern to increase periods of low nutrient loading.

2.6.3 Design Criteria

The Centrate equalization tanks receive Centrate five days a week during the eight-hour dewatering shift, daily flows are reported in Table 2-25. Centrate will be stored in the equalization tanks and recycled to the liquid stream process at a constant rate over a 24-hour period. Alternatively, the centrate could be recycled to equalize the nitrogen loading to the secondary process. Centrate equalization equipment sizes are reported in Table 2-26. Two tanks are recommended to allow one to be temporarily taken offline for cleaning or maintenance. The total volume is sized based on the peak week Centrate flow. Each tank will use a VFD controlled mixer to keep particulates in suspension, mixers are sized based on a horizontal mixer orientation and industry standard 0.19 to 0.27 hp/1,000 cubic feet (Water Environment Federation, 2012). The mixer speed will be controlled based on tank level to prevent overmixing and air entrainment. A VFD driven feed pump controls Centrate flow back to the liquid stream, a small manual daily adjustment of the VFD will be required to adjust for daily Centrate volume fluctuations. During peak Centrate flow or when one tank is offline the Centrate return period will have to be shortened.

Table 2-25: Ancillary Equipment Design Criteria

	Average Annual	Max Month	Max 2-Week	Max Week	Max Day
Centrate Flow (gpd)	333,270	429,377	496,653	513,472	530,291

Table 2-26: Ancillary Equipment Design Criteria

Centrate Equalization Sizing	Value
Tank Volume (MG)	0.29
Number of Tanks	2
Mixer Power (hp)	8.0
Feed Pump (gpm)	400

2.6.4 Centrate Odor Control

Centrate equalization tanks can be a source of odor; therefore, it is recommended that air from the headspace of the tanks be collected and treated in the centralized odor treatment system. The amount of foul air will be sized to maintain a slight negative pressure within the tank preventing odorous air emissions to the atmosphere. This is based on a number of items including liquid level in the tank, common leakage rates for the tank material and leakage rates from access hatches and other openings.

2.7 FOOD WASTE RECEIVING AND FEED TO SHF DIGESTERS

RP-5 SHF currently accepts food waste for processing, digestion, and dewatering. Several alternatives were evaluated for handling, processing, and digestion of food waste. These alternatives included the following:

1. No food waste digestion (base case)
2. Co-digestion of food waste with biosolids at RP-5
3. All food waste processed and digested at RP-5 SHF

The selected alternative was to send all food waste for processing and digestion to RP-5 SHF and bring the food waste digestate to RP-5 for dewatering. The main drivers for this decision are

- Avoidance of potential for digester upsets at RP-5 due to inconsistent food waste composition
- Elimination of dewatering operations at RP-5 SHF, which have reportedly been a bottleneck due to limited capacity
- Economies of scale associated with dewatering both digested solids streams together (food waste digestate from SHF and biosolids digestate from RP-5)
- Avoidance of costs associated with centrate discharge to IEBL at RP-5 SHF

2.7.1 Description of Approved Food Waste project

A new food waste receiving station will be constructed at RP-5 SHF to increase the quantity of food waste that can be processed. The Agency decided that receiving station will be designed to handle only food waste in the form of a pre-processed slurry; FOG will not be accepted. The new receiving station will be capable of processing up to 50,000 gallons per day of food waste. The receiving station will have two days of storage capacity to accommodate processing of food waste deliveries that are expected to occur only on weekdays. In addition, the approved project considers transferring all digestate from RP-5 SHF to RP-5 for dewatering. A new digestate transfer pump station and pipeline will be installed at SHF. The digestate will be transferred to the RP-5 digested sludge holding tank prior to dewatering.

Sending digestate to RP-5 will require an additional centrifuge to handle the increased dewatering load. The cake storage silos must also increase in size due to the added dewatered solids. Additionally, the centrate equalization tanks and pumps must be larger due to the increased centrate quantity. The major equipment required for the food waste approved project is listed below in Table 2-27.

Table 2-27: Equipment for Food Waste Approved Project

Item	Units	Value	Remarks
Food Waste Storage/Receiving Tanks	-	2	
Capacity, each	gallons	50,000	
Food Waste Mixing/Transfer Pumps	-	2	1 per storage/receiving tank
Capacity, each	gpm	850	
SHF Digester Feed Pumps	-	2	
Capacity, each	gpm	35	
Digestate Transfer Pumps	-	2	
Capacity, each	gpm	70	
Additional Centrifuge	-	1	
Capacity, each	gpm	300	

2.7.2 Schematic and Preliminary Facility Layout

The new food waste receiving station at RP-5 SHF will be capable of processing up to 50,000 gallons per day. A schematic for the receiving station is shown in Figure 2-15 and a layout of the facility is shown in Figure 2-16.

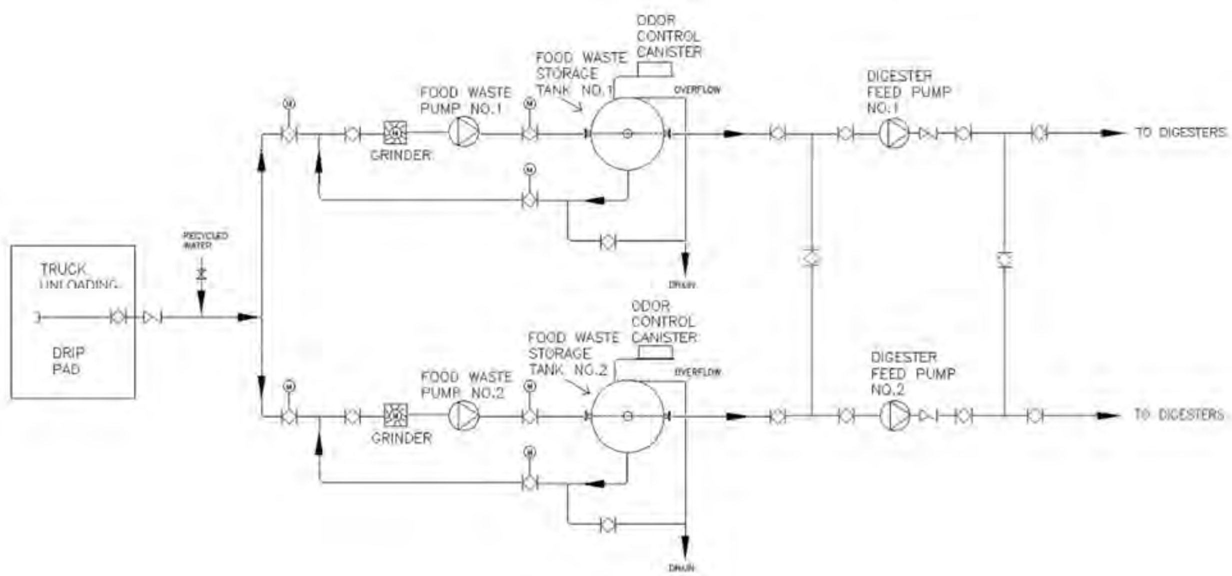


Figure 2-15: Food Waste Receiving Schematic

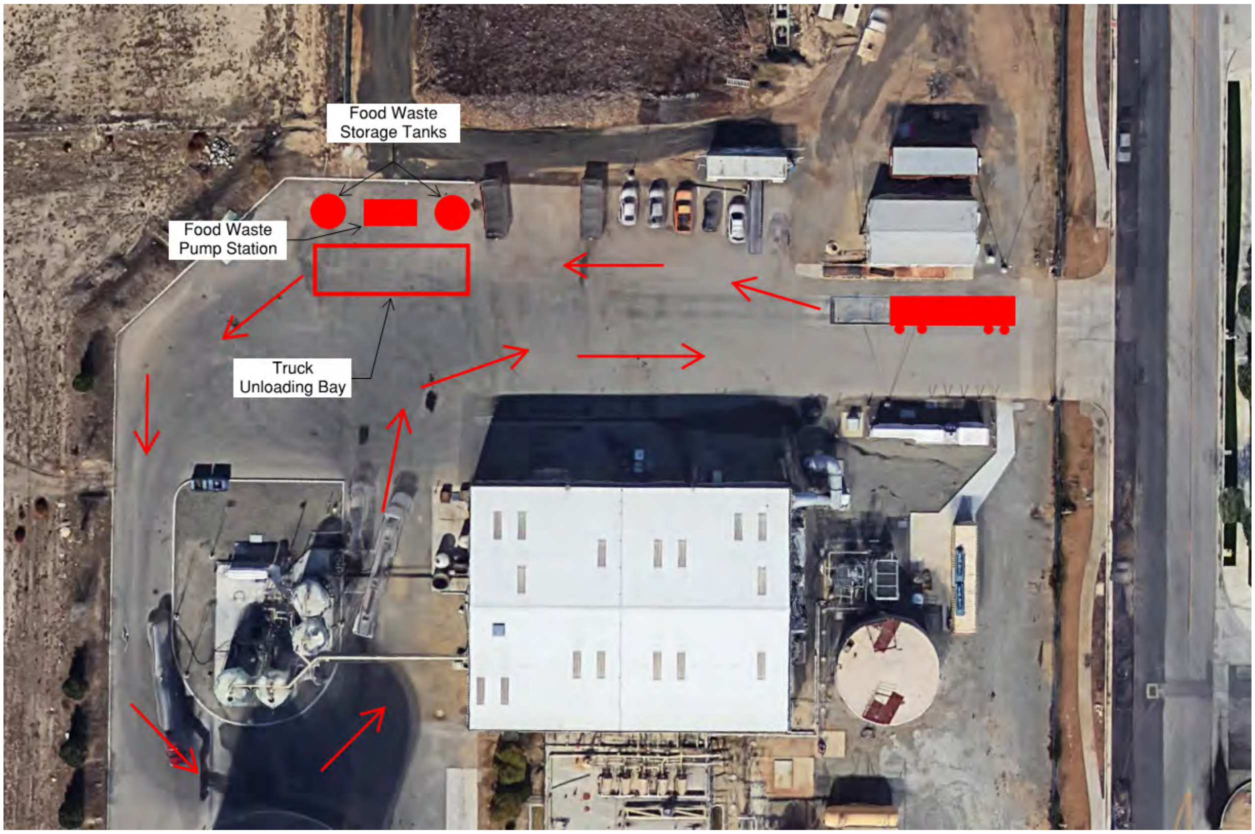


Figure 2-16: Food Waste Receiving Station Layout

The digestate pipeline route from RP-5 SHF to RP-5 is shown in Figure 2-17. This route follows the Agency's easements and does not encroach on properties owned by others. The pump station location is yet to be determined and must be coordinated with IBE (current operators of SHF).

Figure 2-17: Digestate Pipeline Route

2.7.3 Design Criteria

The food waste receiving station will be designed to handle 50,000 gallons per day of pre-processed slurry. The digestate pump station and pipeline will be designed to transfer up to 100,000 gallons per day of digestate – 50,000 gallons per day of the pre-processed slurry plus approximately 50,000 gallons per day of industrial food waste (currently being received at SHF).

Design of the food waste receiving station considers deliveries of 70,000 gallons per day (equivalent to 14 truckloads) five days per week, providing two days of storage over the weekend.

2.8 DIGESTER GAS UTILIZATION

The digester gas produced from biosolids digestion at RP-5 and food waste digestion at RP-5 solids handling facility (SHF) will be beneficially used in a digester gas utilization facility. Several alternatives were evaluated (Refer to Chapter 9) for the utilization of digester gas, including:

1. Utilize existing IC engines for cogeneration
2. Install microturbines for a new cogeneration system
3. Install gas turbines for cogeneration with combined gas from RP-5 and RP-1
4. Install gas upgrading system for production of renewable natural gas (RNG) for pipeline injection
5. Install gas upgrading system for production of compressed natural gas (CNG) for vehicle fuel

The utilization of the existing IC engines is the selected alternative for digester gas utilization. This alternative was chosen because it allows the Agency to fully utilize the capacity of the REEP engines while simultaneously exploring alternative gas utilization technologies, such as production of CNG or RNG.

2.8.1 Description of Approved Digester Gas Utilization Project

Digester gas produced at RP-5 will be sent to a new gas conditioning facility prior to utilization in the two existing REEP engines. Gas conditioning will consist of H2S removal, moisture removal (refrigeration), and siloxane removal. After treatment, the gas will be used either in the boiler facility to produce hot water for digester heating or in the REEP IC engines for cogeneration of heat and power. The digester gas from RP-5 will be combined with food waste digester gas from RP-5 SHF to be used together in the IC engines. The existing heat recovery system at REEP will be modified to allow for waste heat recovery and to use heat produced by the engines for digester heating. Selective Catalytic Reduction (SCR) units will be added to treat the exhaust from the two IC engines at REEP to meet SCAQMD NOx emission limits. Further, additional gas treatment is required at SHF for projected gas quantities. Two iron sponges, similar to existing, will be installed at SHF. The equipment required for the approved gas utilization project is listed below in Table 2-28.

Table 2-28: Required Equipment for Gas Utilization Project

Item	Units	Value	Remarks
RP-5 H2S Removal Units	-	4	iron sponges or SulfaTreat™
Capacity, each	scfm	230	lead/lag configuration; adequate for 2035 gas projections
Refrigeration Unit		1	
Capacity, each	scfm	460	
Siloxane Removal Units	-	4	
Capacity, each	scfm	230	lead/lag configuration; adequate for 2035 gas projections
SCR Units	-	2	one for each IC engine
RP-5 SHF H2S Removal Units	-	2	iron sponges
Capacity, each	scfm	TBD	Will match capacity of existing units

2.8.2 Schematic and Preliminary Facility Layout

A schematic of the approved digester gas utilization project is shown below in Figure 2-18. The acid gas and methane-phase gas are blended together and will be pulled through the H2S removal units by two booster blowers. The refrigeration system will chill the gas and moisture is removed in the form of condensate, which incidentally removes a portion of siloxanes from the gas. The downstream siloxane removal system will remove the remainder for siloxanes from the gas. Gas will then either be used at the boilers or will be boosted to about 45 psi to mix with SHF gas and be used at the REEP engines.

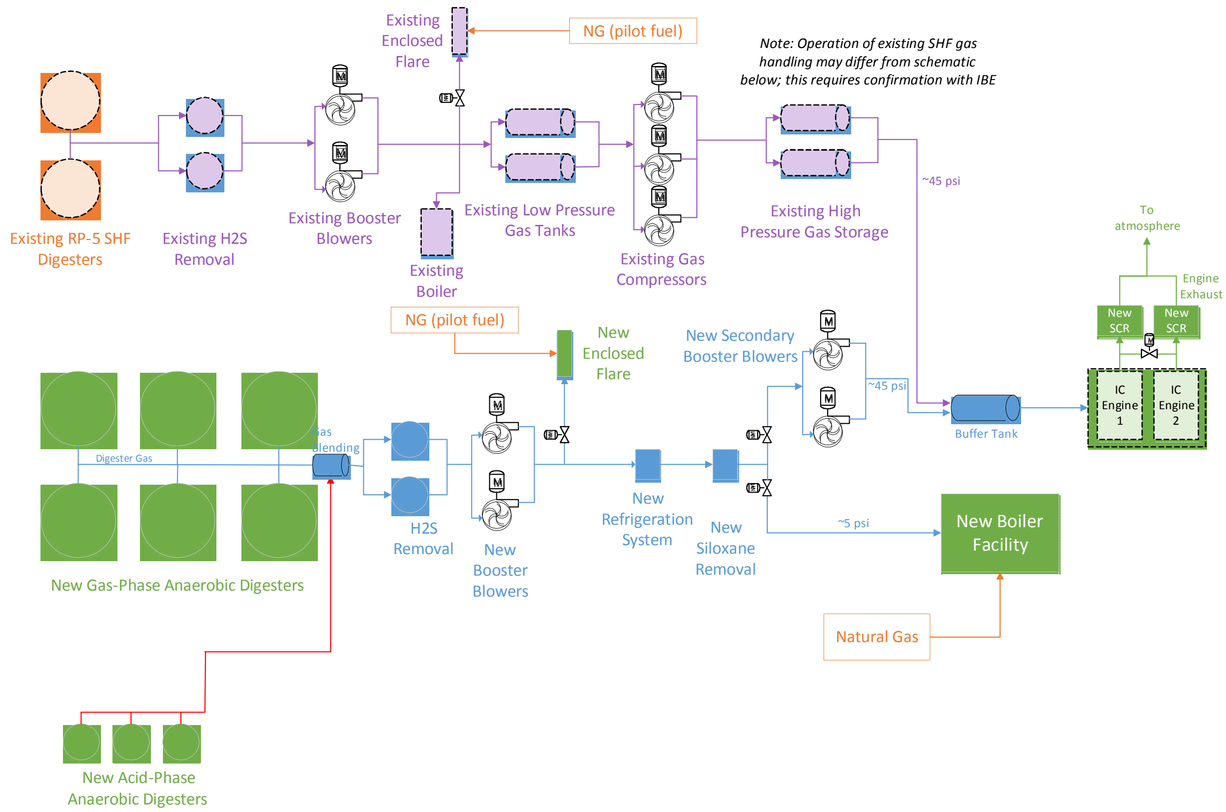


Figure 2-18: Gas Utilization Schematic

A layout of the gas treatment facility is shown in Figure 2-19.

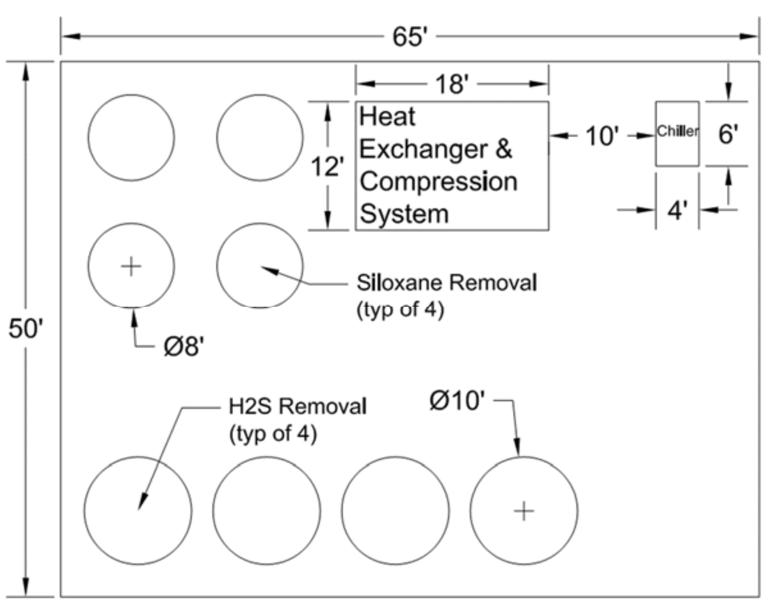


Figure 2-19: Gas Conditioning System Layout

A schematic of the modified heat recovery system is shown in Figure 2-20.

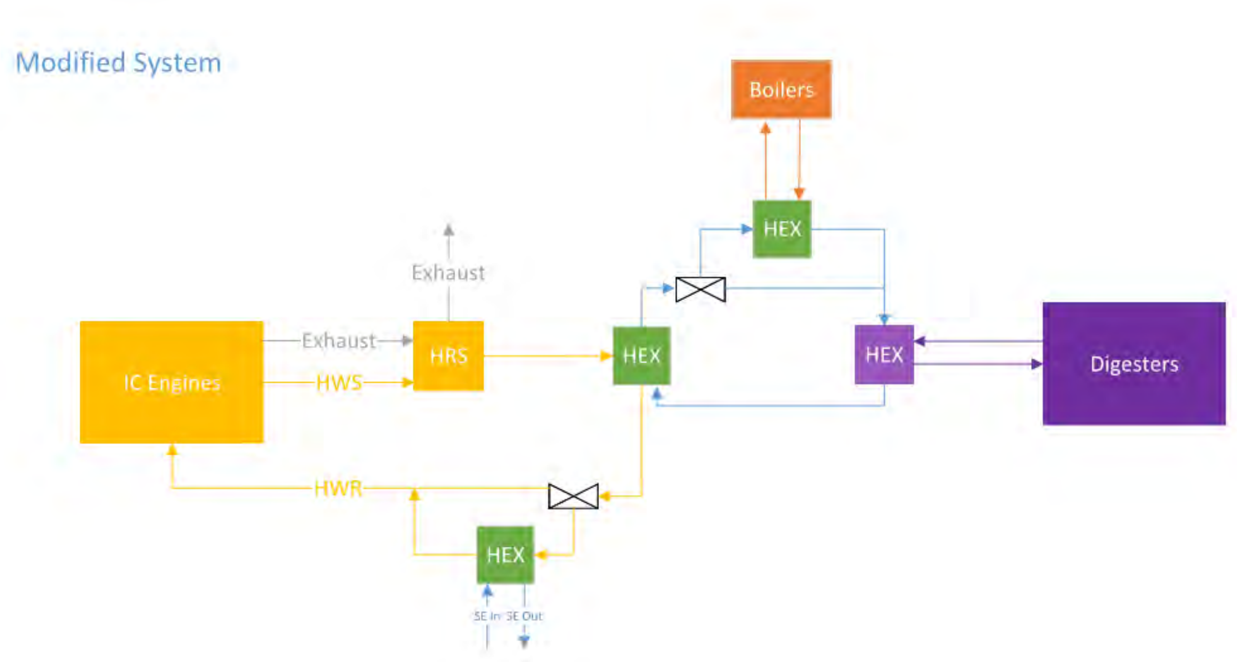


Figure 2-20: Preliminary Schematic of Modified Heat Recovery System

2.8.3 Design Criteria

Gas projections for RP-5 were calculated using the sludge quantity projections and the following assumptions:

- RP-5 Digester volatile solids reduction (VSR) = 60%
- Gas production = 15 cu. ft. per lb VS reduced

Gas projections for RP-5 SHF were calculated based on existing data and the following assumptions:

- 3,200 cu. ft. per wet ton of EBS
    - Based on OCSD pilot study and operational data from EBMUD
- 2,230 cu. ft. per wet ton of industrial food waste
    - Based on operational data from RP-5 SHF

The projections of gas quantities (based on annual average biosolids and food waste and FOG availability) for both sources (RP-5 and RP-5 SHF) are shown in Table 2-29.

Table 2-29: Digester Gas Quantity Projections

Digester Gas Source	Year					
	2025	2030	2035	2040	2045	2060
Digester Gas from RP-5 Biosolids Only	360	420	460	500	530	570
Digester Gas from food waste at RP-5 SHF	590	600	620	640	660	700

2.9 BIOGAS CONDITIONING / WASTE GAS BURNERS

2.9.1 Background

Waste gas burners are required anaerobic digestion safety equipment used for eliminating excess biogas. The selection of two-phase anaerobic digestion technology for RP-5 solids digestion will produce two separate biogas streams. The first phase or acid-phase vessels will generate a relatively small amount of lower quality gas containing methane, CO_2 and H_2S. The second digestion phase will be a thermophilic (digester) process and will generate a gas with favorable methane concentrations for beneficial utilization; in the Renewable Energy Efficiency Project (REEP) or the boilers.

With two very different biogas streams generated by the selected digestion method, an evaluation of varying technologies and process configurations was performed to determine the most efficient and cost-effective approach for waste gas burning.

To meet air permitting regulations two ultra-low emissions enclosed flares were the selected waste gas flaring alternative. The recommended configuration combines the acid-phase and the digester gas streams into a single flow stream which can then either be flared or beneficially utilized.

The selected waste gas technology was based on screening results, regulatory emission standards, and a Business Case Evaluation (BCE). The selected waste gas technology and configuration for 2-phase digestion is a refinement of the initial discussion in Volume III, Chapter 7. This was due to the increased capital and Net Present Value (NPV) costs incorporated into each alternative.

2.9.2 Description of Approved Waste Gas Elimination Technology

Ultra-low emissions enclosed flares (shown in Figure 2-21) have a similar configuration to standard enclosed combustion flares in regard to the flaring section with an enclosed tower that promotes flame stability. Where the ultra-low emissions flare differs is the addition of specialized combustion air blowers and an extended fuel/air pre-mixing section upstream of the flare to ensure a consistent homogenous air/fuel mixture. These blowers bring in additional air that is blended with the biogas prior to combustion resulting in lower emissions of criteria pollutants.

Figure 2-21: Enclosed Flare

Note: Image courtesy of John Zink

2.9.3 Waste Gas Elimination Schematic and Preliminary Layout

Figure 2-22 shows the recommended preliminary waste gas elimination schematic. Redundancy is recommended for both the H_2S removal system and the gas booster blowers, both of which are critical components in the waste gas flaring process.

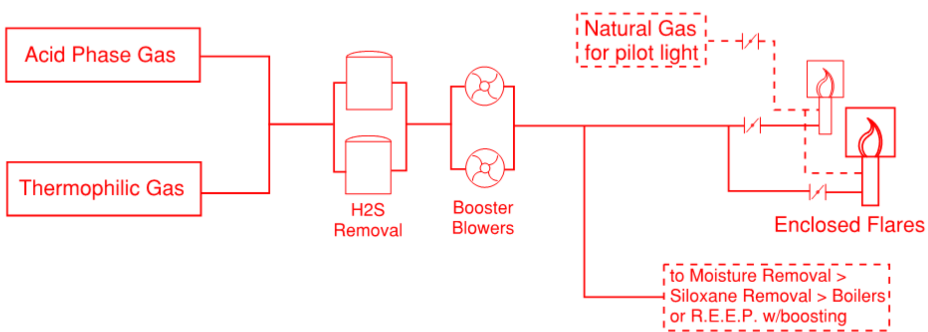


Figure 2-22: Waste Gas Flare PFD

The preliminary layout of the waste gas elimination equipment places the gas treatment equipment and the flares near the boiler, dewatering, and power buildings south of the digesters is presented in Figure 2-23 below.

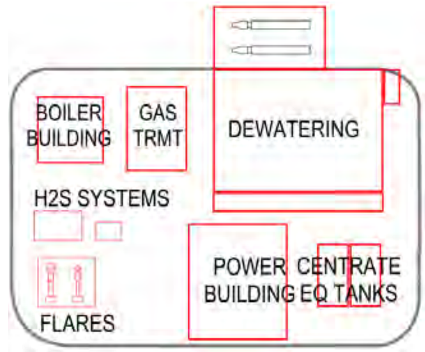


Figure 2-23: Waste Gas Facility Layout

2.9.4 Waste Gas Elimination Design Data

Design criteria for flare type and sizing are set by calculated biogas production and regulatory emissions requirements. The flares are sized to handle the peak design gas production when all other utilization equipment is out of service, but also to handle small amounts of gas when production minimally exceeds utilization. For this reason, two independent flares, of differing sizes and capacities, are needed to turn down for the lower gas flows while still meeting the maximum case capacity. Biogas design criteria for the waste gas flares are presented in Table 2-30.

Table 2-30: Biogas Design Criteria

Parameter	Unit	Value
Biogas Production, average day (2045)	scfm	530
Biogas Production, peak day (2045)	scfm	965
Gas Peaking Factor (waste gas)	--	1.5
Design Biogas to Flares, maximum (2045)	scfm	1,450
Design Acid-Phase Gas, maximum (2045)	scfm	100
Treated Biogas H_2S Concentration to the Flares	ppmv	40
Methane Concentration in Thermophilic Gas	% mole	~60
Methane Concentration in Acid-Phase Gas	% mole	13-25

As a data reference for the biogas constituents, digester gas sample data from the IEUA RP-1 facility was obtained, for both acid-phase and thermophilic phase. The RP-1 facility also utilizes a two-phase digestion method. The 40 ppm H_2S concentration to the flares is a plant-wide air quality requirement per SCAQMD Rule 431.1 that will be achieved by the H_2S removal system.

2.10 IEBL DISCHARGE STATION RELOCATION

The existing IEBL Discharge Station is currently located at the RP-2 site along El Prado Road, near the intersection with the southern end of Mountain Avenue, as shown in Figure 2-24. The IEBL Discharge Station is a septage receiving station that receives trucked liquid waste from permitted haulers and discharges the waste to the 27-inch diameter IEBL (previously known as the Santa Ana Regional Interceptor – SARI) on El Prado Road. The IEBL is owned by the Santa Ana Watershed Project Authority (SAWPA) while IEUA owns and maintains the IEBL Discharge

Station and the 8-inch diameter sewer lateral connecting the Discharge Station to the IEBL. The IEBL transports salty wastewater to the Orange County Sanitation District's wastewater treatment facility (Plant 2) in Huntington Beach.

Due to the anticipated decommissioning of RP-2, the station may be relocated to a site within the Agency-owned Solids Handling Facility at Mountain Avenue and Flower Street, as discussed in Chapter 5 of this volume.

The proposed configuration of the relocated facility is illustrated below.

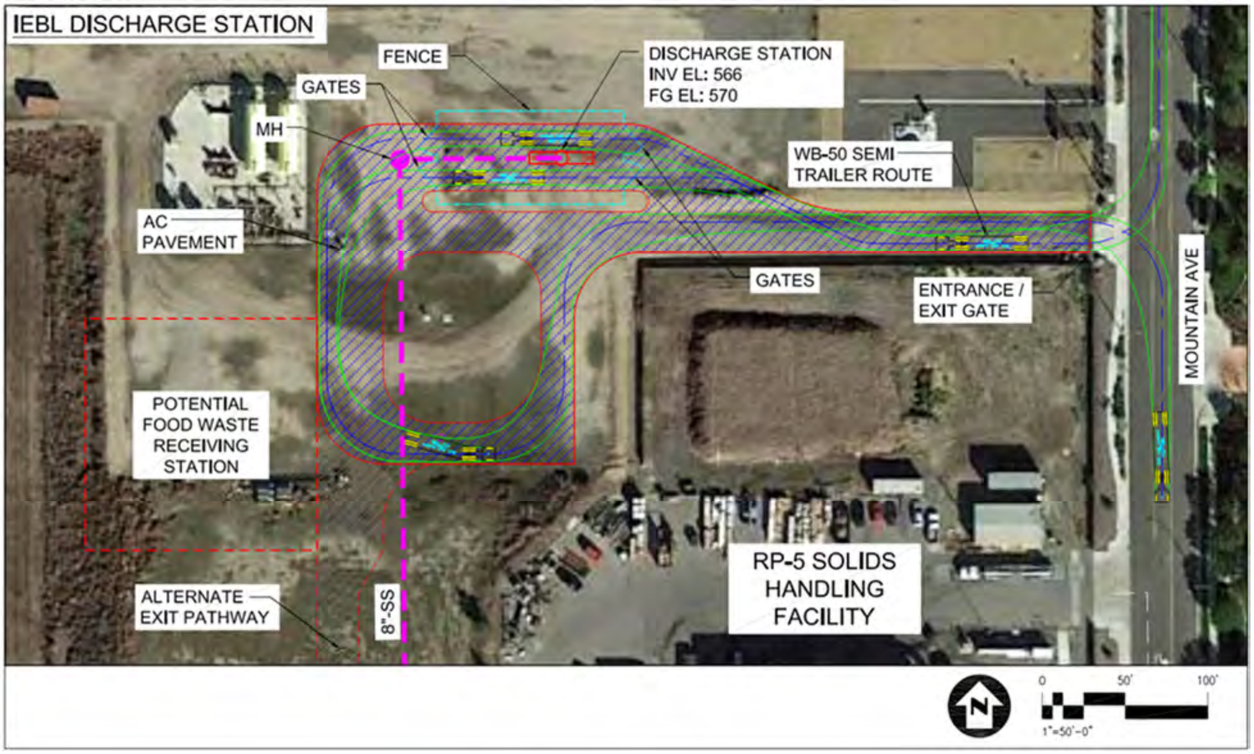


Figure 2-24: Site Layout

The IEBL Discharge Station will feature a dump station manhole, which receives septage/permitted liquid waste from two receiving stations, and two catch basins that capture any stormwater and spray down waste. Each receiving station will include a quick disconnect coupling where hauling trucks can connect in order to discharge the waste. The incoming waste is analyzed for pH, temperature, conductivity, and sulfide—ensuring the waste does not surpass the IEBL disposal limits. A magnetic flow meter and automatic sampler will be provided in the station. The dump station manhole will route septage/liquid waste through an 8-inch diameter pipeline to the 27-inch diameter IEBL. In this design, the septage is contained and odors are limited from escaping into the atmosphere.

The IEBL Discharge Station will have restricted access where only permitted waste haulers can enter the fenced area. Several instruments and electrical equipment will be provided at the IEBL Discharge Station as listed below:

- (4) Proximity Card Readers
- (4) Gate Controllers, (4) Gate Actuators with (3) Detector Loops each

- (2) Flood Light/Camera supported on a Pole
- Modular Enclosure: Lighting Panel, SCADA Panel, Security Panel, and Irrigation Controller

Two of the proximity card readers will be provided outside of the fence, where the trucks enter the station while the other two are featured inside of the fence, where the trucks exit the station. Signals from the card readers will be sent to the gate controllers, which together with the detector loops, control the opening and closing of the gates. A pair of flood lights and cameras will be included at the station to enforce site security. The panels in the modular enclosure will receive and transmit signals to the communication panel located in the SHF plant control station.

2.11 RP-2 LIFT STATION RELOCATION AND NEW FORCE MAIN

The existing RP-2 lift station receives raw sewage from the 24-inch diameter Mountain Avenue interceptor sewer, 10-inch diameter Chino Institute for Women (CIW) sewer, 10-inch diameter Butterfield force main, and recycled flows from the solids treatment facilities at RP-2, as shown in Figure 2-25. The 10-inch diameter CIW sewer receives sewage flows from both the CIW and the El Prado Golf Course clubhouse. Each pump discharges into a 14-inch diameter discharge pipe connecting to a 24-inch diameter discharge manifold that conveys flows to the RP-5 headworks.

Due to the anticipated decommissioning of RP-2, the lift station must be relocated above the Prado Dam inundation area above elevation 566, and the associated collection/discharge system must be modified to account for these changes.

As discussed in Chapter 4 of this volume, the new location for the lift station has been established at the Agency-owned Solids Handling Facility along Mountain Avenue near Flowers St., as shown in Figure 2-25.

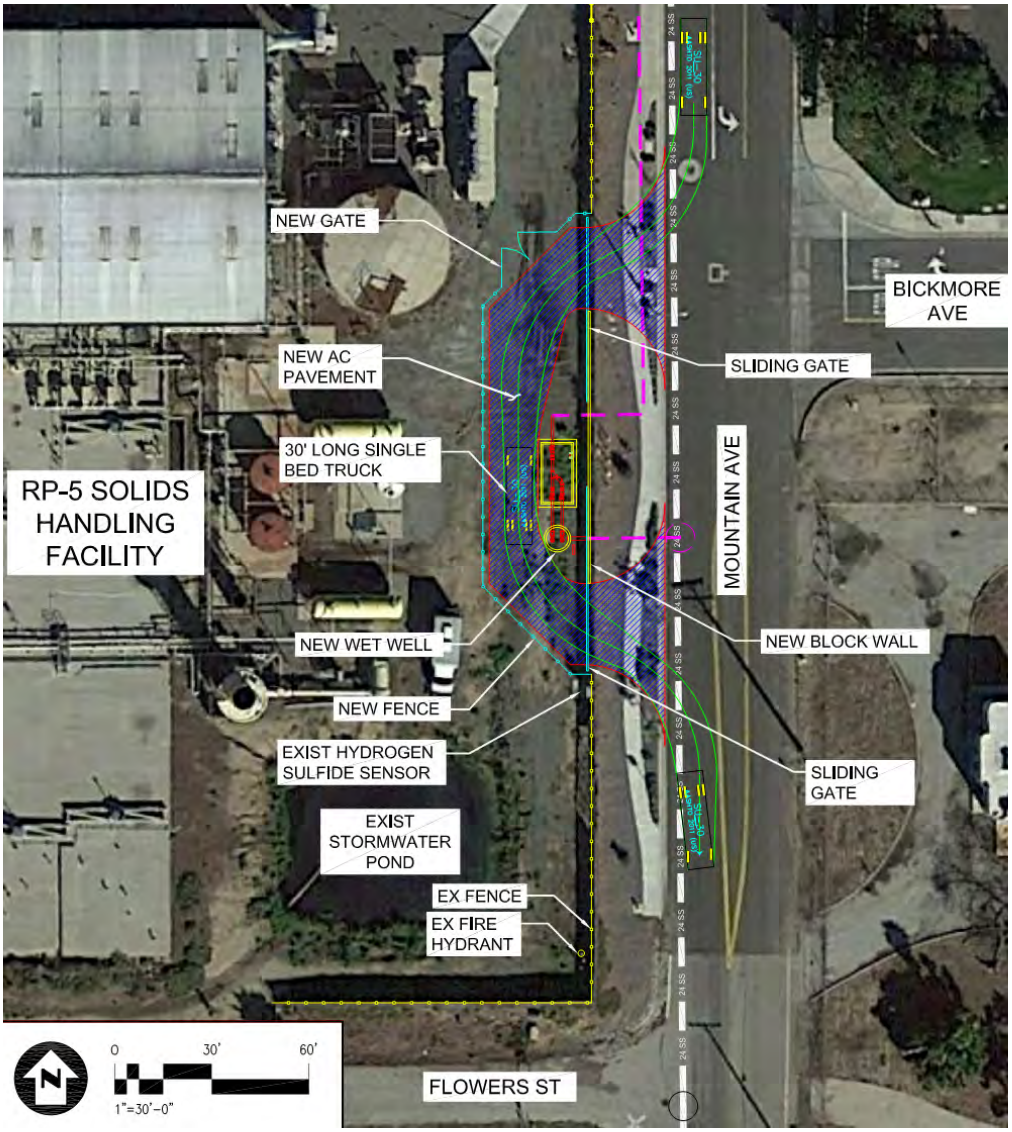


Figure 2-25: RP-2 Lift Station

As discussed in Chapter 4, the collection system will be modified such that the CIW flows and golf course will be handled separately in a joint agreement with City of Chino. Thus, the flows to be received and pumped at the new location include the Mountain Avenue Sewer, thus the facility will be renamed as the Mountain Avenue Lift Station. The Butterfield Ranch lift station flows are discussed in a separate subsection below, and will be combined with the discharge of the Mountain Avenue Lift Station.

2.11.1 Lift Station Capacity

The Agency has forecasted that the average flows of the new lift station would be 0.3 mgd from present day to year 2040 and 0.4 mgd from 2040 to 2060. Assuming a peaking factor of 2.0, the design flow for this lift station is 0.8 mgd or 560 gpm. Therefore, two pumps (one duty and one standby) sized at 0.8 mgd (560 gpm) each will be provided to meet peak flows.

2.11.2 Influent Gravity Sewer

The invert elevation of the Mountain Avenue sewer manhole ("Manhole No. 8") at Kimball Avenue is 559.96[1]. The invert elevation of the Mountain Avenue sewer near SHF was assumed to be 556.75, with the assumption that the Mountain Avenue sewer shares the same slope as the Mountain Avenue.

The sewage flows in the Mountain Avenue interceptor sewer will be intercepted with a new diversion manhole. With a minimum slope of 0.0056 ft/ft and pipe diameter of 10 inches, the velocity of sewage flowing full through the pipe will be 3.0 ft/s. To reach the new wet well, the pipeline will be approximately 40 feet in length and enter at an invert elevation of 556.53.

2.11.3 Sewage Force Main

The lift station will discharge the sewage flows to an existing manhole on the Kimball Avenue Interceptor sewer, approximately 3,200 feet north on Kimball Avenue, through a new force main. The recommended size of the force main is 12-inch diameter, accounting for the flows from Butterfield Ranch as discussed below.

2.11.4 Wet Well

The wet well will have an inner diameter of 8 feet and be constructed of either concrete or fiberglass material. The wet well will contain two rail-mounted submersible pumps. The lead pump will stop at an elevation no less than the minimum submergence level per the selected pump's specifications. The bottom of the wet well elevation will be set to limit the motor to maximum six starts per hour.

2.11.5 Valve/Meter Vault and Appurtenances

Each pump will discharge into a respective 8-inch diameter lateral pipe, which will enter a valve/meter vault containing check valves, isolation valves, and a flow meter. One of the 8-inch discharge pipelines will include a quick disconnect coupling for a bypass connection to a portable pump in the event of pump failure.

The wet well and valve vault will be provided with ventilation pipes. Additionally, a 2-inch diameter drain will be provided between the valve/meter vault and wet well to drain any water that may enter the vault. A plant water line will be provided for a hose bibb connection to allow for wash down activities. An above ground control panel in a NEMA-4 enclosure will be provided along with electrical conduits for power and signaling. The pumps will be designed to alternate daily to extend the life of the pumping equipment.

In-line emergency storage of 60 minutes at peak flow (or 4,500 ft^3) can be provided in the 24-inch diameter Mountain Avenue Interceptor sewer that connects to the 8-inch diameter influent pipeline. The MCC will be equipped with a manual transfer switch and connectors suitable for connection to a potable emergency generator in the event of a power failure. Alternatively, by connecting to the provided quick disconnect coupling, a portable pump can pump flows in the wet well to the force main and bypass the submersible pumps should it be required.

[1] Project No. EN97004-3 Phase II record drawings.

2.12 BUTTERFIELD RANCH LIFT STATION MODIFICATIONS AND FORCE MAIN EXTENSION

The Butterfield Ranch Lift Station (Figure 2-26), located about 2 miles south of RP-2, is owned and operated by the City of Chino.

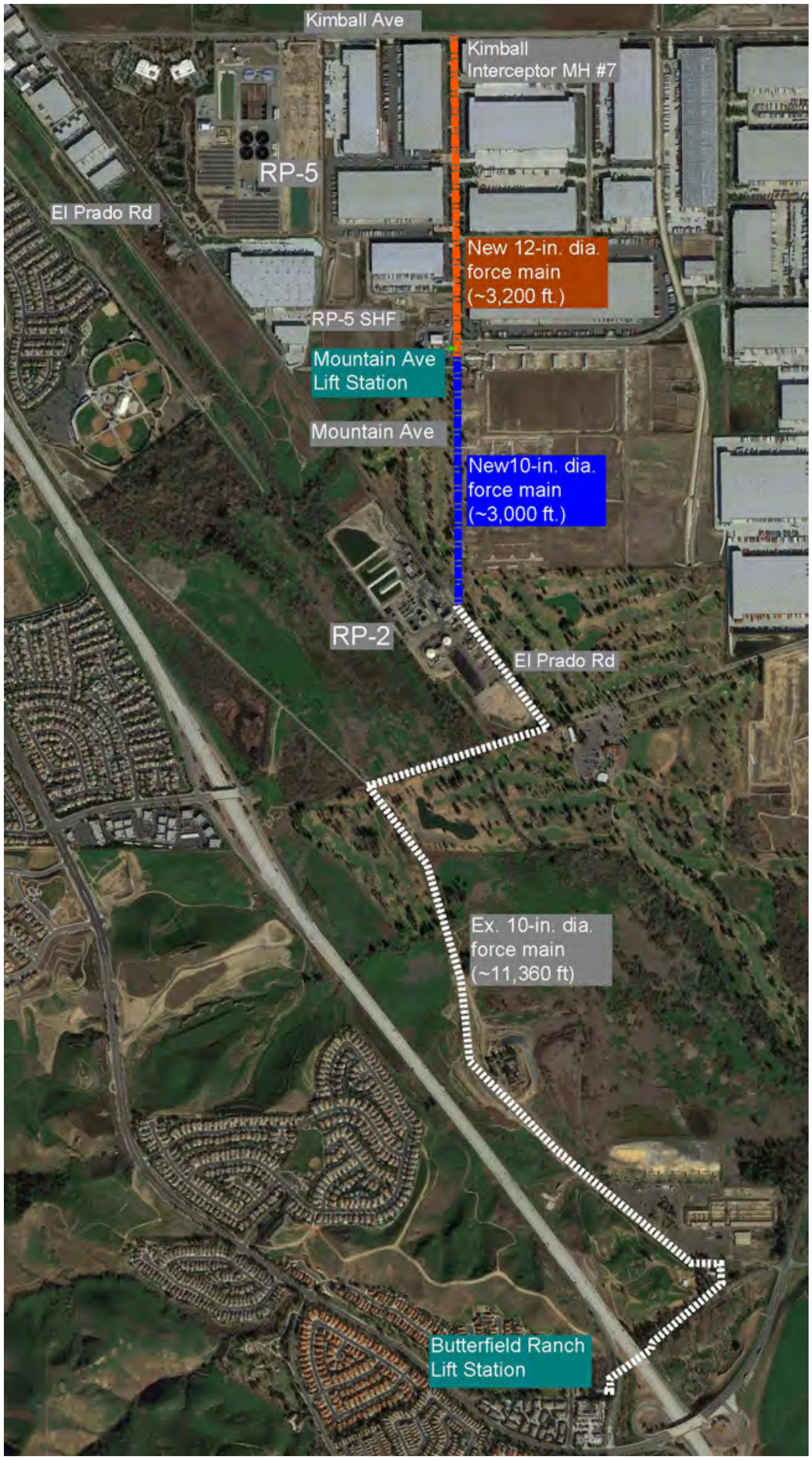


Figure 2-26: Butterflied Ranch Lift Station

Due to the anticipated decommissioning of RP-2, the flows from Butterfield Ranch will need to be conveyed to the Kimball Avenue Interceptor as illustrated herewith, combining the Butterfield Ranch peak flows of around 1100 gpm, with the Mountain Avenue flows of up to 560 gpm. The Butterfield Ranch force main will be extended by 3000 feet of 10-inch diameter, followed by 3200 feet of 12-inch force main once the flows are combined with the new lift station for Mountain Avenue.

The Butterfield Ranch lift station pumps, motors, and electrical system will be modified for the additional power requirements to achieve the additional pump discharge head required to pump the additional distance and to a somewhat higher elevation. The details of these modifications will be determined during the design phase when the current and future flows are confirmed with the City of Chino.

2.13 SCADA INTEGRATION

The following list of Process Control Narratives (PCNs) is required to complete the project (see Table 2-31 through 2-33). The developed PCNs will be used by the system integrator or vendor to program the PACs and PLCs to monitor and operate as required. The PCNs will ensure that the new processes will seamlessly connect to and operate through the upcoming SCADA Enterprise System.

Table 2-31: Liquids Treatment Processes PCNs

Process/Area	System/Equipment PCN
Influent Pump Station	Influent Pumps
Headworks	Mechanical Bar Screens Fine Screens Screenings Washer/Compactors Grit Removal System, Pumps, Classifiers
Primary Clarifiers	Primary Sludge Grinders Primary Sludge Pumps Primary Scum Pumps Primary Diversion Structure Gates Ferric Chloride Storage and Feed System
Odor Control System	Foul Air Fans Recirculation Pumps
Aeration Basins	Aeration Blowers Aeration Flow Control Valves Anoxic Mixers MLR Pumps
MBR Treatment System	Membrane Tank Inlet Gates Membrane Tank Drain Valves Membrane Tank Drainage Pump Scour Air Blowers Scour Air Valves Filtrate Pumps/Valves Backpulse Pumps/Valves Chemical CIP Pumps/Valves Citric Acid Feed Sodium Hypochlorite Feed Compressed Air System

Process/Area	System/Equipment PCN
	RAS Pumps WAS Pumps
Methanol Injection System	Metering Pumps
UV Disinfection System	UV Channel Outlet Gates UV Lamps Wiper System Off-Spec Valve
Off-Spec and Emergency Storage	EOP Pumps
Recycled Water & Plant Water Systems	Non-chlorinated plant water pump station Sodium Hypochlorite Feed System for Recycled Water Storage Chlorinated plant water pump station

Table 2-32: Solids Treatment Processes PCNs

Process/Area	System/Equipment PCN
Solids Thickening	Rotary Drum Thickeners Sludge Blending and Thickener Feed Pump Station Emulsion Polymer Make-up and Feed System Thickened Sludge Pumps Filtrate Return Pumps Sump Pumps
Digestion	Acid and Methane Phase Sludge Feed Control Valves Sludge Mixing Pumps Sludge Heating System Sludge Transfer Pumps Sludge Grinders Ferric Chloride Injection System Sump Pumps
Dewatering & Cake Storage	Centrifuges Dewatering Feed Pumps Emulsion Polymer Make-up and Feed System Dewatered Sludge Cake Conveyors and Pumps Flosperse Feed System for Struvite Control Building Sump Wastewater Pumps Cake Storage Silos Dewatered Sludge Pumps Truck Loading Screw Conveyors
Centrate Equalization and Pumping	Centrate Transfer Pumps
Gas Purification and Flare System	H2S Removal System Siloxane Removal System Enclosed Flare System
Renewable Energy Efficiency Project (REEP)	SCRs – Engine Exhaust Cleaning Systems Heat Recovery System
Boilers	Boilers

Table 2-33: Offsite Facilities PCNs

Process/Area	System/Equipment PCN
Mountain Ave Lift Station	Lift Pumps
Chino Hills Butterfield Ranch Lift Station	Lift Pumps
IEBL Discharge Station	Septage Receiving Station
Food Waste System	Food Waste Receiving at SHF Digestate Transfer from SHF to RP-5

The primary goal of the IEUA SCADA Master Plan is to define the path to build a fully integrated and uniform SCADA system that provides enterprise-wide control and the information necessary to optimize operations. To fulfill this goal, IEUA is currently migrating all facilities to a Rockwell Automation PlantPAx SCADA Enterprise System. Parsons assumes that the migration of the SCADA system at RP-5 will be complete and operational prior to this expansion project.

The IEUA Engineering Design Guidelines was developed to provide consulting engineers/designers the design preferences of the Agency to improve consistency and efficiency to project deliveries. Within these guidelines are the Agency's standards for PAC programming, High-Performance HMI programming and Alarm Management. It also includes the Agency's preferences for control panel components, control system hardware and software and instrumentation.

2.14 PERMITTING

Required permits include the following:

- Permits for on-site facilities:
  - City of Chino building permit (IEUA may be exempt from local requirements for wastewater treatment process related facilities)
  - Chino Valley Fire District fire protection permit
  - State Water Resources Control Board waste discharge requirements amendment
  - South Coast Air Quality Management District air quality permit to construct
  - Title 22 Permit Update
- Permit for Off-Site Facilities:
  - City of Chino Public Works Department encroachment permit for new pipelines in public rights-of-way
  - City of Chino Hills building permit (for the Butterfield Lift Station upgrade)

2.15 DETAILED PROJECT SCHEDULE

The project milestone schedule is shown below in Table 2-34.

Table 2-34: Project Milestone Schedule

Project Milestone	Target Date (mm/dd/yyyy)
30% Design Completion	11/01/2017
50% Design Completion	04/01/2018
85% Design Completion	11/01/2018
100% Design Completion	04/01/2019

2.16 OVERALL PROJECT COST ESTIMATE

The overall solids train project cost estimate is shown below in Table 2-35.

Table 2-35: Solids Treatment Approved Project Cost Estimate

Item Number	System Components	Cost
RP-5 Solids Treatment Facility Costs		
1	Piping from CCWRF to Thickening & Pump Modifications @ CCWRF	$303,000
2	Thickening (RDTs)	$6,012,000
3	Acid Phase Digestion	$3,041,000
4	Gas Phase Digestion - Thermophilic/Mesophilic	$19,287,000
5	Digested Sludge Storage/Backup Digester	$6,000,000
6	Dewatering, Cake Storage, and Truck Loadout	$24,780,000
7	Odor Control Ductwork to Centralized Odor Control	$1,140,000
8	Centrate Handling	$720,000
9	Boilers	$2,945,000
10	Digester Gas Conditioning	$1,845,000
11	Waste Gas Flares	$2,700,000
12	Power Generation	$1,002,000
13	Heat Recovery Modifications	$505,000
14	Power Building	$1,250,000
15	Site Work	$4,770,120
16	Base Biosolids Cost (w/o SHF)	$76,300,120
17	Overhead & Profit, Inflation, Bonds & Insurances, Contingency (30%)	$49,671,000
18	Total Biosolids Construction Cost (w/o SHF)	$125,971,000
19	Design & Administration	$25,194,000
20	**Total Biosolids Project Cost (w/o SHF)**	**$151,165,000**
Food Waste Receiving Costs		
22	HSW Receiving Station	$2,000,000
23	Transfer Pumps & Piping from SHF to Digested Sludge Storage	$296,000
24	RP-5 SHF Dewatering Centrifuge, Hopper, Centrate and Building Allocation	$2,750,000
25	Digester Gas Storage	$0
26	RP-5 SHF Digester Gas Conditioning & HP Storage	$654,000
27	Base SHF Cost Allocation	$5,700,000

Item Number	System Components	Cost
28	Overhead & Profit, Inflation, Bonds & Insurances, Contingency (30%)	$3,711,000
29	Total SHF Construction Cost	$9,412,000
30	Design & Administration	$1,882,000
Total Food Waste Receiving Cost		**$11,294,000**
Total Project Cost (RP-5 Solids and Food Waste)		**$162,459,000**

Additional items were identified as preferred options during development of the approved project, but due to anticipated budgetary limitations, were not included in the base project. These optional items may be added to the base project during the next project phase, budget allowing. The cost estimate for these additional optional items are shown in Table 2-36.

Table 2-36: Solids Treatment Approved Project Additional Project Options Cost Estimate

Additional System Components	Additional Project Cost	Description
Acid Phase Digestion	$2,098,000	1 Acid (0.37 MG) (1+1)
Gas Phase Digestion - Thermophilic/Mesophilic	$9,139,000	1 Thermo (1.52 MG) (3+1)
Dewatering, Cake Storage, and Truck Loadout	$4,557,000	1 centrifuge @ 300 gpm Cake storage, 2 x 6,000 cf

THIS PAGE INTENTIONALLY LEFT BLANK.

APPENDIX 2-A: RP-5 SOLIDS TREATMENT FACILITY APPROVED PROJECT DETAILED COSTS

THIS PAGE INTENTIONALLY LEFT BLANK.

Mountain Ave. Lift Station - Pre-packaged Cost Estimate						
Item No.	**Description**	**No. of Items**	**Units**	**Quantity**	**Unit Cost ($)**	**Cost ($)**
	EQUIPMENT					
1	Pre-packaged Lift Station			1	$ 112,000	$ 112,000
2	Excavation			1	$ 14,000	$ 14,000
	Equipment Installation		%		15%	$16,800
	Electrical & Instrumentation, SCADA interface		%		15%	$16,800
	FITTINGS, VALVES, FLOW METER					
3	8"x6" Reducer			2	$ 239	$ 500
4	8-inch 90-degree elbow			4	$ 350	$ 1,400
5	8-inch tee			1	$ 521	$ 521
6	Quick disconnect			1	$ 1,200	$ 1,200
	Equipment Installation		%		45%	$1,629
	PIPELINE					
7	8-inch Pipeline	50	ft	1	$ 192	$ 10,000
8	10-inch Pipeline	40	ft	1	$ 200	$ 8,000
9	8-inch Pipeline	3100	ft	1	$ 192	$ 595,000
	MANHOLE MODIFICATIONS					
10	Connect to Kimball manhole, add diversion manhole			1	$ 20,000	$ 20,000
	SITE IMPROVMENTS					
11	Block Wall			1	$ 9,700	$ 9,700
12	AC Pavement			1	$22,000	$ 22,000
13	Slide Gate			2	$ 9,000	$ 18,000
14	Security Gate			1	$3,200	$ 3,200
15	Fence			1	$ 7,425	$ 7,425
	Total Equipment and Structures Cost					**$858,000**
3.1	Sales Tax		%		9%	$28,400
	Unit Cost Estimate					**$886,000**

IEBL Discharge Station Approved Project Cost Estimate						
Item No.	**Description**	**No. of Items**	**Units**	**Quantity**	**Unit Cost ($)**	**Cost ($)**
	Piping					
1	8-inch Pipeline	750	ft	1	$ 192	$144,000
	STRUCTURES					
2	IEBL Structures			1	$ 11,300	$11,300
3	Manhole			1	$ 7,000	$7,000
	Installation			1	15%	$2,745
	Excavation			1	$ 15,000	$15,000
	CIVIL WORK					
4	Asphalt Paving			1	$ 186,000	$186,000
	SECURITY					
6	Security gate, card reader, bollards			1	$ 15,000	$15,000
	Electrical & Instrumentation		%		15%	$2,250
	EQUIPMENT					
7	Equipment Relocation		LS	1	$10,000	$10,000
	Total Equipment Cost					
	Subtotal of above items					**$393,000**
3.1	Sales Tax		%		9.000%	$11,000
	Construction Cost Estimate					**$404,000**

Thickening Facility Cost Estimate						
Item No.	Description	No. of Items	Units	Quantity	Unit Cost ($)	Cost ($)
	Equipment					
1.1	Rotary Drum Thickener (Parkson) Package	4	each	4	$190,000.00	$760,000
1.2	Feed Solids Pumps	4	each	4	$40,668.74	$162,675
1.3	Thickened Sludge Pumps	4	each	4	$21,543.76	$86,175
1.4	Effluent Pumps	2	each	2	$31,329.84	$62,660
1.5	Polymer System	1	each	1	$257,000.00	$257,000
	Structures					
1.6	Concrete for Blending Tank	1	CY	116	$800.00	$92,800
1.7	Concrete for Filtrate Tank	1	CY	25	$800.00	$20,000
1.8	Excavation for Blending Tank	1	CY	716	$16.90	$12,100
1.9	Excavation for Filtrate Tank	1	CY	130	$16.90	$2,197
1.10	Ground level builing	1	sqft	10950	175	$1,917,000
1.11	Basement level builing	1	sqft	6750	148.75	$1,005,000
	Total Equipment Cost					**$1,328,509.70**
	Total Structures Cost					**$3,049,097.40**
2.1	Equipment Submittal and Testing markups		%		15%	$114,000.00
2.2	Equipment Installation		%		23%	$305,557.23
2.3	Mechanical and Piping		%		23%	$305,557.23
2.4	Electrical and I&C		%		30%	$398,552.91
2.5	Coatings		%		6.5%	$86,353.13
2.6	Odor Control		scfm	1800	$40.88	$73,584.00
	Total Cost					**$5,661,211.60**

Digestion (incl Digested Sludge Storage) Facility Cost Estimate						
Item No.	Description	No. of Items	Units	Quantity	Unit Cost ($)	Cost ($)
	Acid Silo Equipment					
1.1	Acid Silo Cover - 30 ft dia	2	each	2	$54,122.00	$108,244
1.2	Acid Silo Mixer - Pumped Mixing System (1 Per Digester)	2	each	2	$129,550.00	$259,100
1.3	Acid Silo HEX (1 Duty + 0 Stand-By Per Digester)	2	each	2	$150,000.00	$300,000
1.4	Acid Silo Solid Circulation Pump (1 Duty Per Digester + 1 Stand-By Every Two Digesters)	3	each	3	$61,000.00	$183,000
1.5	Silo Feed Control Valves (1 Per Silo)	2	each	2	$6,500.00	$13,000
	Digester Equipment					
1.6	Digester Feed Control Valves (1 Per Digester)	4	each	4	$6,500.00	$26,000
1.7	Digester Cover	4	each	4	$384,868.16	$1,539,473
1.8	Digester Mixer - Pumped Mixing System (1 Per Digester)	4	each	4	$295,290.50	$1,181,162
1.9	Digester HEX (1 Duty + 0 Stand-By Per Digester)	4	each	4	$150,000.00	$600,000
1.10	Digester Feed Pump	2	each	2	$61,000.00	$122,000
1.11	Digester Solid Circulation Pump (1 Duty Per Digester + 1 Stand-By Every Two Digesters)	6	each	6	$61,000.00	$366,000
1.12	Digester Withdrawal/Standpipe Pump (1 Duty + 1 Stand-By Per Digester)	6	each	6	$35,000.00	$210,000
1.13	Inline Grinder (1 Duty Per Digester + 0 Stand-By Every Two Digesters)	4	each	4	$25,000.00	$100,000
1.14	Standpipe, 316 SS, 36" (1 Per Digester)	4	each	4	$40,000.00	$160,000
1.15	Digester Gas Foam Suppression Tank (1 Per Digester)	4	each	4	$44,000.00	$176,000
1.16	Digester Gas PVRV Assembly (1 Per Digester)	4	each	4	$8,000.00	$32,000
1.17	Digester Gas Safety Selector Valve (1 Per Digester)	4	each	4	$16,000.00	$64,000
1.18	Sump Pumps (2 Duty + 2 Stand-By)	4	each	4	$5,000.00	$20,000
	Acid Silo Structures					
1.21	Acid Silo Site Preparation Allowance	1	sqft	7550	$19.50	$147,225
1.22	Acid Building	1	sqft	4000	$175.00	$700,000
1.23	Acid Silo Tank	1	cyd	900	$800.00	$720,000
1.24	Acid Silo wall coating	1	sf	4000	$20.00	$80,000
	Digester Structures					
1.25	Digestion Site Preparation Allowance	1	sqft	59750	$19.50	$1,165,125
1.26	Digester Building	1	sft	22667	$175.00	$3,966,725
1.27	Digester Tank	4	cyd	4710	$800.00	$3,768,000
1.28	Digester wall coating	1	sf	25000	$20.00	$500,000
1.29	Walkway Allowance Per Digesters	4	ea	4	$200,000.00	$800,000
1.30	Bridges Allowance Per Digesters	4	ea	4	$200,000.00	$800,000
1.31	Miscellaneous Structural Work per Digester	4	ea	4	$ 200,000.00	$800,000
	Total Equipment Cost					**$5,459,978.66**
	Total Structures Cost					**$13,447,075.00**
2.1	Equipment Submittal and Testing markups		%		15%	$818,996.80
2.2	Equipment Installation		%		30%	$1,637,993.60
2.3	Walkways, Bridges, Elevator, and Misc Installation		%		30%	$720,000.00
2.4	Acid Silo and Digester Cover Installation		%		80%	$1,318,173.31
2.5	Mechanical and Piping		%		25%	$2,308,785.59
2.6	Electrical and I&C		%		25%	$2,308,785.59
2.7	Acid Silo and Digester and Wall Coating Installation		%		55%	$319,000.00
	Total Cost					**$28,338,788.55**

Dewatering Facility Cost Estimate						
Item No.	Description	No. of Items	Units	Quantity	Unit Cost ($)	Cost ($)
	Equipment					
1.1	Centrifuge (Andritz)	4	each	4	$680,000.00	$2,720,000
1.2	Dewatering Feed Grinders	4	each	4	$25,000.00	$100,000
1.3	Dewatering Feed Pumps	4	each	4	$55,000.00	$220,000
1.4	Polymer Solution Feed Pumps	4	each	4	$25,000.00	$100,000
1.5	Cake Transfer Pumps	4	each	4	$550,000.00	$2,200,000
1.6	Polymer Make up Units	2	each	2	$75,000.00	$150,000
1.7	Polymer Solution/ Mix Age Tanks	2	each	2	$15,000.00	$30,000
1.8	Bridge Crane	1	each	1	$190,000.00	$190,000
1.9	Cake Storage Bin & Truck Loading Equipment	1	each	1	$2,500,000.00	$2,500,000
2	Truck Scales	2	each	2	$60,000.00	$120,000
	Structures					
2.2	Base Building	1	sf	28000	$300.00	$8,400,000
2.3	Truck Loading	1	sf	4250	$250.00	$1,062,500
	Total Equipment Cost					**$8,330,000.00**
	Total Structures Cost					**$9,462,500.00**
2.1	Equipment Installation		%		30%	$2,873,850.00
2.2	Equipment Submittal and Testing markups		%		15%	$1,249,500.00
2.3	Mechanical and Piping		%		20%	$1,915,900.00
2.4	Electrical and I&C		%		25%	$2,394,875.00
2.5	Coatings		%		4%	$409,836.00
2.6	Odor Control		scfm	21,800	$40.88	$891,184.00
	Total Cost					**$27,527,645.00**

Centrate Equalization Cost Estimate						
Item No.	Description	No. of Items	Units	Quantity	Unit Cost ($)	Cost ($)
	Equipment					
1.1	Transfer Pumps	2	each	2	$50,000.00	$100,000
1.2	Mixing Pumps	2	each	2	$40,000.00	$80,000
	Structures					
2.2	Concrete for EQ tanks	1	cf	78000	$5.95	$464,100
2.3						
	Total Equipment Cost					**$180,000.00**
	Total Structures Cost					**$464,100.00**
2.1	Equipment Installation		%		5%	$9,450.00
2.2	Equipment Submittal and Testing markups		%		5%	$9,000.00
2.3	Mechanical and Piping		%		10%	$18,900.00
2.4	Electrical and I&C		%		10%	$18,900.00
2.5	Coatings		%		5%	$9,945.00
2.6	Odor Control		%		5%	$9,945.00
	Total Cost					**$720,240.00**

Boiler Facility Cost Estimate						
Item No.	Description	No. of Items	Units	Quantity	Unit Cost ($)	Cost ($)
	Equipment					
1.1	Boilers	3	each	3	$250,000.00	$750,000
1.2	Boiler Stacks	3	each	3	$10,000.00	$30,000
1.3	Boiler hot water circulation pumps	3	each	3	$5,000.00	$15,000
1.4	Air separator and expansion tanks	1	ls	1	$15,000.00	$15,000
1.5	Main hot water circulation pumps	2	each	2	$10,000.00	$20,000
1.6	Make-up water and Btu meters	1	ls	1	$5,000.00	$5,000
1.7	Sump Pumps (1 Duty + 1 Stand-By)	2	each	2	$7,500.00	$15,000
	Structures					
1.6	Site Preparation Allowance	1	sqft	10000	$19.00	$190,000
1.7	Central heating building	1	sqft	3800	$300.00	$1,140,000
	Total Equipment Cost					**$850,000.00**
	Total Structures Cost					**$1,330,000.00**
2.1	Equipment Installation		%		30%	$255,000.00
2.2	Equipment Submittal and Testing markups		%		15%	$127,500.00
2.3	Mechanical and Piping		%		20%	$170,000.00
2.4	Electrical and I&C		%		25%	$212,500.00
	Total Cost					**$2,945,000.00**

RP-5

Digester Gas Utilization Approved Project Detailed Costs

Description	No. of Items	Units	Unit Cost ($)	Cost ($)	Comments
SCR	2	LS	$500,000	$1,000,000	2 SCRs for existing engines
Gas Conditioning @ RP-5	-	LS	$1,000,000	$1,000,000	H2S & siloxane removal
SHF Gas Conditioning	2	LS	$96,300	$192,600	H2S removal
REEP Heat Recovery System Modifications					
Hot water piping		LS	$140,000	$140,000	
Water to water HEX		LS	$100,000	$100,000	
Transfer pumps	2	LS	$14,000	$28,000	
Total Equipment Cost				$2,320,600	
Total Equipment + Structures Cost				$2,460,600	
Sales Tax		%	9.000%	$208,854	
Equipment Installation		%	45%	$1,044,270	
Civil Site Work, Mechanical, Plumbing & HVAC		%	10%	$146,060	
Electrical & Instrumentation		%	10%	$146,060	
Construction Cost Estimate				$4,006,000	

Inland Empire Utilities Agency
A MUNICIPAL WATER DISTRICT

Evaluation of the Decommissioning of RP-2

Predesign Report
Volume III, Chapter 3

February 28, 2017

submitted by

PARSONS

in association with

Brown AND Caldwell

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

THIS PAGE INTENTIONALLY LEFT BLANK.

CHAPTER 3: EVALUATION OF THE DECOMMISSIONING OF RP-2

3.1 INTRODUCTION

3.1.1 Background

Regional Plant No. 2 (RP-2) is located in the city of Chino within the flood zone upstream of the Prado Dam, on land leased from the United States Army Corps of Engineers (USACE). To increase the available Orange County water storage, USACE will increase the maximum operational water level upstream of the dam by raising the Prado Dam Spillway. This increase will cause RP-2 to be within the 566-foot (ft) inundation area.

In accordance with the easement renewal for the right-of-way for RP-2 granted by USACE that extended the easement term from May 9, 2010, to May 8, 2035, Inland Empire Utilities Agency (IEUA) is required to remove RP-2 facilities and restore the plant site and utilities upon expiration or termination of the easement. The decommissioning of the plant facilities must follow USACE and US Environmental Protection Agency (EPA) requirements supplemented by state requirements.

RP-2 has been in operation since 1960 and includes both liquid and solids treatment facilities; however, only the solids treatment facilities are currently in operation. Since the inception of RP-5 in 2002, liquids have been sent to RP-5 for treatment, leaving the liquid treatment facilities abandoned in place. RP-2 receives solids from the Carbon Canyon Water Recycling Facility (CCWRF) and RP-5; therefore, new solids treatment facilities would need to be constructed at RP-5 (forecasted for 2022) before the decommissioning and demolition of RP-2 solids treatment facilities.

RP-2 has a design capacity of 26.4 million gallons per day (mgd) for solids treatment. The solids treatment train consists of the following processes: gravity thickening or dissolved air floatation thickening, two-stage anaerobic digestion process, digester gas cogeneration, and dewatering through belt presses (or standby centrifuges). Centrate and thickener overflows are sent to the RP-2 lift station, which sends liquids to RP-5 for treatment. The dewatered solids are hauled to the Inland Empire Regional Composting Facility for further treatment to produce Class A compost. A process flow diagram (PFD) of the solids treatment configuration is illustrated in Figure 3-1.

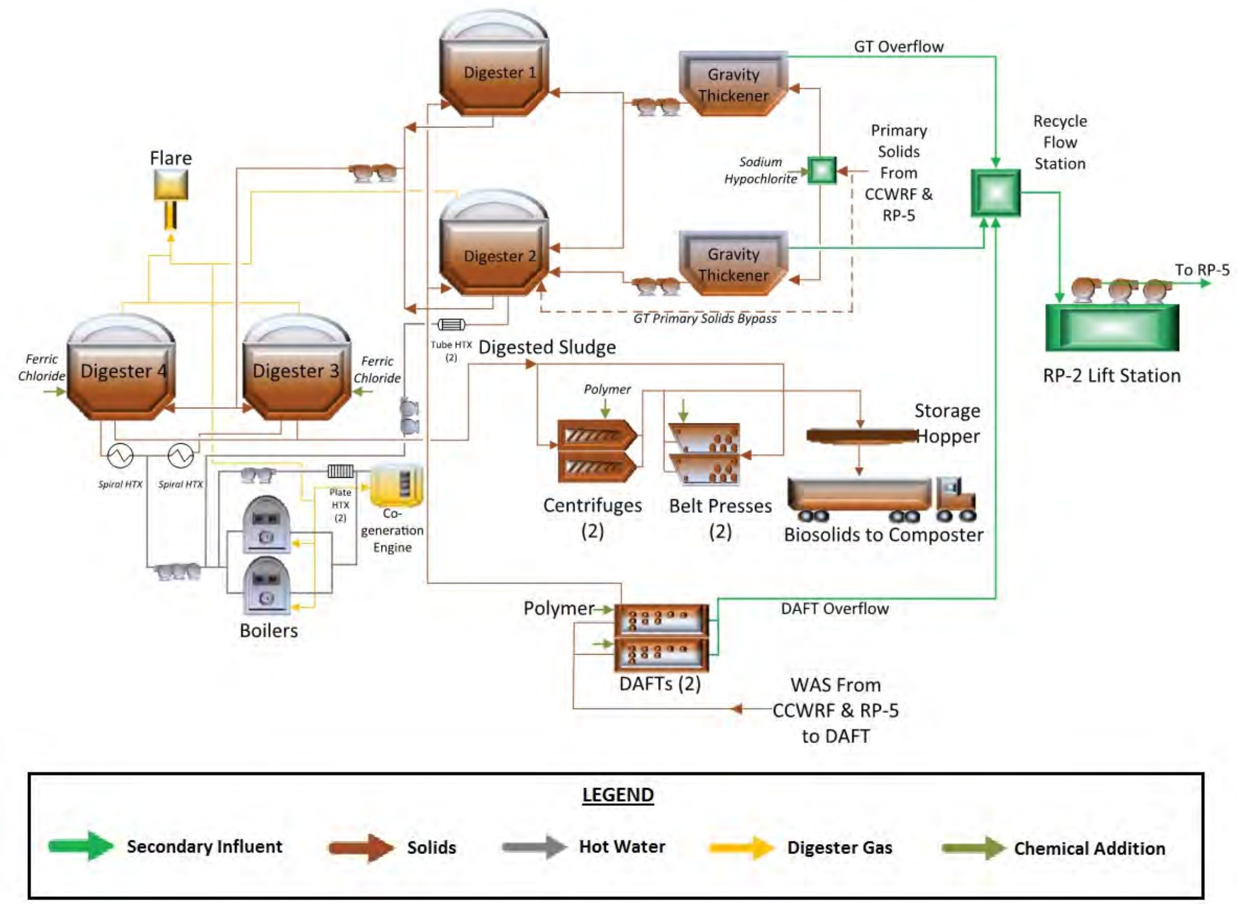


Figure 3-1: RP-2 Process Flow Diagram

Aside from the RP-2 facilities, the IEBL Discharge Station would also require decommissioning and demolition. The relocation of the IEBL Discharge Station is discussed later in this report.

3.1.2 Understanding and Approach

This chapter presents preliminary cost estimates of demolishing the facilities at RP-2 and requirements for restoring the site and utilities. The elements addressed in this chapter for decommissioning and performing demolition activities include the following:

- Identification of infrastructure and equipment to be removed and preliminary demolition cost estimates
- Environmental Site Assessment for the identification and sampling of recognized environmental conditions (RECs) in the soil, surface water, and groundwater
- Hazardous Waste Survey for the identification and sampling of any buildings or materials that are suspected of containing hazardous materials
- Regulatory coordination with affected agencies: USACE, Regional Water Quality Control Board (RWQCB), Santa Ana Watershed Project Authority (SAWPA), State of California Division of Occupational Safety and Health (Cal/OSHA), City of Chino, and South Coast Air Quality Management District (SCAQMD)

- Identification of required permits and notifications
- Liquids, biosolids, solid waste, and industrial waste management and disposal
- Site restoration requirements

3.2 PRE-DEMOLITION ACTIVITIES

While the demolition of RP-2 cannot occur until RP-5 solids train facilities have been commissioned and the RP-2 Lift Station has been replaced by changes in the collection system, several activities can commence earlier.

3.2.1 Environmental Site Assessment

An Environmental Site Assessment (ESA) is required in order to assess the extent of soil and groundwater contamination, if any, and provide as needed recommendations for remediation. The ESA is conducted in phases, known as Phase I and Phase II, as discussed below.

The objective of the Phase I ESA, already completed and provided in Volume IV of this Pre-Design Report (PDR), was to evaluate if past or current site activities have resulted in "recognized environmental conditions (RECs)" as defined in ASTM E1527-13. Reconnaissance of the site and adjacent properties were performed to document current land usage and existing operations. In addition, inquiries were made with regulatory agencies that had knowledge of possible RECs. Based on the results of this evaluation, recommendations for Phase II sampling to address identified RECs were compiled.

As a result of the completion and analysis of the Phase I ESA, Phase II ESA may commence in the coming months to confirm/quantify the presence of hazardous materials in the soil and/or groundwater. The activities involved in Phase II include: collection of soil and/or groundwater samples, field work, laboratory analysis, and data reporting. Based upon the results of Phase II, remediation activities (if needed) may be recommended.

3.2.2 Hazardous Materials Presence and Documentation

The SCAQMD requires a pre-demolition, asbestos, and hazardous material survey and notification prior to demolition activities. Because SCAQMD requires the hazardous materials survey to be less than five (5) years old (and no survey on the RP-2 site within that timeframe currently exists), a survey will be required to occur within five years to the start of demolition. The survey should be pursuant to the documentation requirements specified by SCAQMD.

Because some buildings at RP-2 have already been demarked with asbestos presence, RP-2 is known to contain certain hazardous materials. Conducting the survey would further verify and quantify the presence of asbestos and other hazardous materials. Other hazardous materials include (but are not limited to) lead, polychlorinated biphenyl (PCB)-contaminated ballasts in fluorescent light fixtures, PCB-contaminated transformers and capacitors, unused paint, lead paint chips and cylinders, mercury vapor lamps, mercury thermometers and Freon in air conditioners.

The hazardous materials survey involves the following steps:

1. Procure the services of a Certified Asbestos Consultant (CAC), who has Cal/OSHA certification, to inspect the facility for asbestos-containing materials (ACMs) and other hazardous materials.

2. After surveying the site, the CAC will document and collect samples of the suspected materials and send the samples to the laboratory for analysis.

3. The CAC will generate a Survey report documenting the results and other requirements per SCAQMD's Rule 1403 checklist.

3.2.3 Regulatory Coordination

Before the onset of decommissioning and demolition of RP-2 facilities, IEUA will need to coordinate with several regulatory agencies. The regulatory agencies and their roles are discussed in the following subsections.

3.2.3.1 United States Environmental Protection Agency (USEPA)

On February 19, 1993, the USEPA issued a final rule for the use and disposal of sewage sludge, 40 Code of Federal Regulations (CFR), Part 503, which requires that producers of sewage sludge meet certain reporting, handling, and disposal requirements. The State of California has not been delegated the authority to implement this program and therefore, the USEPA is the implementing agency.

Any proposed change in biosolids use or disposal practice from a previously approved practice should be reported to the Executive Officer and EPA Regional Administrator at least 90 days in advance of the change.

3.2.3.2 Regional Water Quality Control Board (RWQCB)

The Santa Ana RWQCB (or Santa Ana Regional Water Board) is part of the State Water Resources Control Board which in turn is part of the California EPA (CalEPA). The RWQCB will be involved in multiple facets of the decommissioning and demolishing activities including: notification of changes in sludge use or disposal practices; issuance of the Construction General Permit; and potential issuance of waste discharge requirements (WDRs) for remediation activities.

Even though the USEPA is the implementing agency of 40 CFR, Part 503, NPDES Permit No. CA8000409 (Order No. R8-2009-0021) issued by the California RWQCB includes sludge and biosolids disposal requirements. The disposal methods of collected screenings, sludge, and other solids removed from liquid wastes were required to be approved by the Regional Water Board's Executive Officer. In addition, for any significant changes in a Discharger's sludge use or disposal practices, the Regional Water Board is required to be notified. Because the transferring of sludge treatment processes from RP-2 to RP-5 constitutes as a significant change, RWQCB should be notified as soon as possible.

RWQCB also issues the Construction General Permit, which is required for projects that disturb one (1) or more acres of soil. The RP-2 site occupies around 40 acres; therefore, the Construction General Permit is required for demolition activities. The Permit Registration Documents (PRDs) are discussed in Section 3.2.4.3.

In the event that land or groundwater remediation is found to be required per the results from the ESA, coordination with RWQCB may also be required. Depending upon the type of remediation applied to RP-2, the RWQCB may issue WDRs (e.g., applying oxidizing agents).

3.2.3.3 Santa Ana Watershed Project Authority (SAWPA)

The SAWPA owns and maintains the Inland Empire Brine Line (IEBL), also known as the Brine Line or the Santa Ana Regional Interceptor (SARI). The IEBL Discharge Station located on the premises of RP-2 connects to the 27-inch (in) diameter SARI line with an 8-in-diameter lateral pipeline. This pipeline along with the Discharge Station would be demolished and capped. The relocated IEBL discharge station will require a new 8-in-diameter lateral connection to the SARI line.

Because the relocated Discharge Station would be on a new premise, SAWPA requires the following:

1.) Contact SAWPA for discharge requirements and costs.
2.) Purchase capacity to dispose and treat the waste.
3.) Complete and submit a Discharger Permit Application (see Section 3.2.4.4).
4.) Submit construction plans for approval to SAWPA and the City of Chino.
5.) Once the contracts are in place, the permit is approved/issued and the lateral line constructed, the tie-in can be made and operation can begin.
6.) The permit will include disposal limits on metals and other specific contaminants, monitoring and reporting requirements, and a variety of other administration requirements

To make the connection to the new SARI line, a new manhole would be constructed on the SARI line wherein the new 8-in-diameter pipeline could connect to.

3.2.3.4 United States Army Corps of Engineers (USACE)

The United States Army Corps of Engineers has leased RP-2 to IEUA since 1960 and has since approved an easement extension through May 8, 2035. In accordance with the renewal of Easement No. DA-04-353-CIVENG-60-242, IEUA is required to remove all RP-2 facilities and restore the premises to the satisfaction of the USACE. If IEUA were to not remove the facilities and restore the premises, the United States can pursue the option of taking over the facilities without compensation or remove the facilities and perform restoration at the expense of IEUA.

3.2.3.5 South Coast Air Quality Management District (SCAQMD)

The EPA has delegated the SCAQMD the authority to enforce the federal asbestos National Emission Standards for Hazardous Air Pollutants (NESHAP) and SCAQMD is the local enforcement authority for asbestos. SCAQMD adopted AQMD Rule 1403 on October 6, 1989, which established survey requirements, notification, and work practice requirements to prevent asbestos emissions from emanating during demolition activities. The survey and notification requirements are discussed in sections 3.2.2 and 3.2.4.4, respectively. SCAQMD may also conduct inspections during the abatement operations.

3.2.3.6 Cal/OSHA

Cal/OSHA (other known as the Division of Occupational Safety and Health) requires notification for asbestos construction work. Any Contractor or employer who engages in asbestos-related work are also required to be registered with Cal/OSHA.

3.2.3.7 City of Chino

The City of Chino and the Fire Marshall with jurisdiction should also be notified of upcoming demolition activities.

3.2.3.8 Communications Plan

IEUA will work with the public agencies with jurisdiction, to conduct the required public information/involvement, post the required notifications in the appropriate publications, websites, and physical locations, and generally respond to relevant inquiries about the scope of upcoming/ongoing work and schedule for completion.

3.2.4 Permits and Notifications

Before the onset of decommissioning and demolition of RP-2 facilities, IEUA will need to secure several permits and file Rule 1403 Notification form.

3.2.4.1 CEQA

The California Environmental Quality Act (CEQA) is a self-executing statute that requires state and local agencies to identify the significant environmental impacts of their actions and to avoid or mitigate those impacts, if feasible. The California Code of Regulations (CCR), Chapter 3 of Title 14 presents the CEQA guidelines, which provide the objectives, criteria and procedures for the orderly evaluation of projects and the preparation of environmental impact reports (EIRs), negative declarations, and mitigated negative declarations (MNDs) by public agencies.

IEUA is responsible for determining whether the decommissioning and demolition activities require an EIR, negative declaration, or MND. Potential environmental effects from demolishing activities could include the introduction of dust, noise, and traffic of heavy equipment.

3.2.4.2 IEBL Discharge Permit

Prior to the connection or discharge to the Brine Line, an IEBL Discharge Permit application will need to be filed with SAWPA. The application requires the submission of monitoring data, wastewater quantities, the proposed lateral connection, etc.

3.2.4.3 Construction General Permit

For any construction or demolition activities such as concrete and asphalt cutting and removal, trenching, and excavation a Construction General Permit is required. To obtain this permit, IEUA is required to electronically file the following documents with the Regional Water Board: Notice of Intent (NOI), Storm Water Pollution Prevention Plan (SWPPP), and other compliance related documents required including the appropriate permit fee.

The SWPPP is required to be written, amended, and certified by a Qualified SWPPP Developer. The SWPPP has two primary objectives: (1) to help identify the sources of sediment and other pollutants that affect the quality of storm water discharges; and (2) to describe and ensure the implementation of best management practices (BMPs) to reduce or eliminate sediment and other pollutants in storm water and non-storm water discharges. The BMPs in the SWPPP should address source control, pollutant control, and treatment control, and the SWPPP must remain on the site throughout the life of the project to protect water quality at all times.

3.2.4.4 AQMD Rule 1403

Contractors removing the asbestos/and or demolishing the ACM structures are required to submit a notification form online in accordance to AQMD Rule 1403. The notification form must be submitted at least ten (10) days before the start of demolition work.

3.3 DEMOLITION ACTIVITIES

3.3.1 Plant Decommissioning and Demolition

3.3.1.1 Site Plan

The facilities to be decommissioned and demolished are shown on the site plan in Figure 3-2 below.

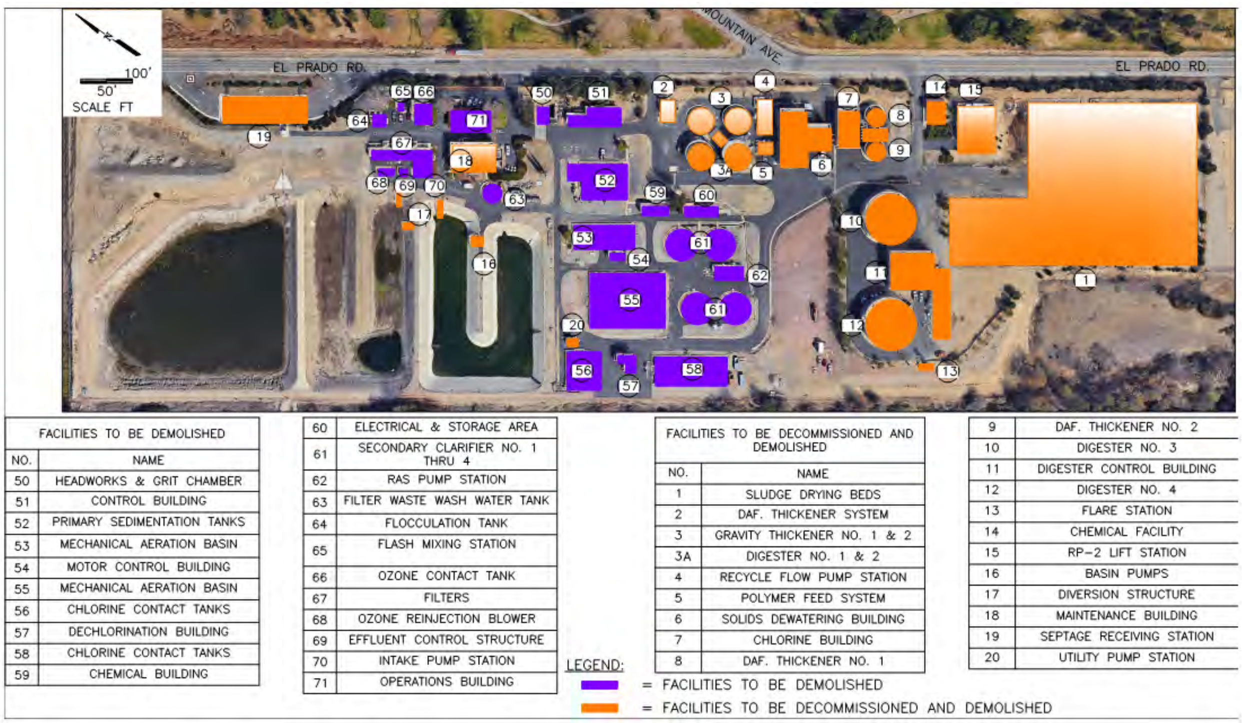


Figure 3-2: RP-2 Site Plan

3.3.1.2 Cost Estimates

A preliminary cost estimate is presented below in Table 3-1. The demolition/site restoration cost for existing facilities was estimated based on record drawings, publicly available aerial photos, and a brief overview tour of the site. Quantity take-offs were prepared based on the record drawings. The estimate is considered incomplete until the Phase 2 ESA and Hazardous Materials Survey can be completed in the coming months, and these values will be updated at that time.

Based upon the Phase 1 ESA, the costs for sampling, analysis, monitoring, modeling, etc. associated with the Phase 2 ESA and hazardous materials survey may range from $625,000 to $787,000. The costs associated with potential abatement of hazardous materials, and potential remediation due to contamination of soils, could be as much as $17 million based on abatement and remediation of most of the site, though the findings of the Phase II ESA and detailed hazardous materials survey will likely result in significantly less cost for abatement and remediation.

Table 3-1: Preliminary Cost Estimate

	Item	
1	Cut Concrete and CMU Walls	$130,000
2	Remove Concrete and CMU Walls	$110,000
3	Concrete and Materials Removal	$330,000
4	Core Drill/Drain Rock	$150,000
5	Compacted Fill	$695,000
6	Grating and Equipment Removal	$460,000
7	Rough Grading	$25,000
8	Electrical Materials Removal	$300,000
9	Yard Piping Removal (8-in-diameter and above)	$560,000
10	Not used	
11	Hazardous Materials Survey	$165,000
12	Phase II ESA	$622,000
13	Waste Management Allowance	$500,000
14	**Hazardous Materials Abatement (Hazardous Materials Survey findings are needed to determine extent of this item)**	**$917,000**
15	Site Restoration Allowance	$200,000
16	**Soils Remediation Allowance (Phase II ESA findings are needed to determine extent of this item)**	**$16,320,000**
17		
18	Subtotal of Items 1 thru 16	**$21,484,000**
19	15% Overhead and Profit	**$3,223,000**
20	8% Inflation to Midpoint of Construction/Remediation	**$1,719,000**
21	4% Bonds and Insurances	**$859,000**
22	Subtotal – Construction Costs	**$27,285,000**
23	30% Contingency (30% of Construction Subtotal)	**$8,186,000**
24	Total Construction Cost	**$35,471,000**
25	Design, Permits, CM, Monitoring, Eng. Contingency (20% of Total Construction Cost)	**$7,094,000**
26	Total Project Cost Estimate	**$42,565,000**

Note: Costs for abatement and remediation are considered highly uncertain till completion of the Phase II ESA and Hazardous Materials Survey

3.3.2 Waste Management

Most of the process liquids, chemicals, fuel, lubricants, solids, and other plant operations and maintenance (O&M) and repair materials and tools are expected to be removed from the site and disposed of properly prior to the initiation of demolition. Remaining materials will need to be tested prior to disposal in the appropriate manner to comply with relevant rules and regulations as determined during the pre-demolition activities.

3.3.3 Abatement and Remediation

There is a distinct probability that asbestos, lead, and other regulated substances will be found in quantities sufficient to require abatement and remediation steps. These steps, and the associated procedures and costs, will be determined during the Phase 2 ESA and Hazardous Materials Surveys to be conducted in the coming months.

3.4 POST-DEMOLITION ACTIVITIES

3.4.1 Site Restoration

The site will be required to be restored to the extent necessary to protect the surrounding environment from dust or other airborne debris, storm-water runoff, and sedimentation. To that end, in all likelihood, there will have to be a durable vegetative or other type of cover compatible with the plans to raise the Prado Dam spillway, and storm water may be allowed to percolate in the existing earthen basins once these are cleared from an environmental standpoint.

THIS PAGE INTENTIONALLY LEFT BLANK.

Inland Empire Utilities Agency
A MUNICIPAL WATER DISTRICT

Evaluation of the Relocation of the RP-2 Lift Station

Predesign Report
Volume III, Chapter 4

February 28, 2017

submitted by

PARSONS

in association with

Brown AND Caldwell

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

THIS PAGE INTENTIONALLY LEFT BLANK.

CHAPTER 4: EVALUATION OF THE RELOCATION OF RP-2 LIFT STATION

4.1 RELOCATION OF THE RP-2 LIFT STATION

4.1.1 Background

The Regional Water Recycling Plant #2 (RP-2; Figure 4-1) Lift Station was constructed in 2010 and includes an inlet box, two wet wells, and three pumps. The lift station receives raw sewage from the 24-inch (in) diameter Mountain Avenue interceptor sewer, 10-in-diameter Chino Institute for Women (CIW) sewer, 10-in-diameter Butterfield force main, and recycled flows from the solid treatment facilities at RP-2. The 10-in-diameter CIW sewer receives sewage flows from both the CIW and the El Prado Golf Course clubhouse. Each pump discharges into a 14-in-diameter discharge pipe connecting to a 24-in-diameter discharge manifold that conveys flows to the RP-5 headworks. A backup generator has been provided if utility power fails.

Figure 4-1: Existing RP-2 Lift Station

4.1.2 Design Objectives

In accordance with the easement renewal for the right-of-way for RP-2 granted by the United States Army Corps of Engineers (USACE) that extended the easement term from May 9, 2010, to May 8, 2035, the Inland Empire Utilities Agency (IEUA) is required to remove all RP-2 facilities, which includes the RP-2 Lift Station. The RP-2 Lift Station is below the 566 elevation associated with the Prado Dam inundation area. Therefore, under the agreement established with the USACE, IEUA is required to decommission, demolish, and remove the RP-2 Lift Station and its associated appurtenances and restore the site and utilities. The decommissioning of the RP-2 Lift Station is discussed in Chapter 3 of Volume III.

The flows that currently enter the RP-2 Lift Station will need to be rerouted to the influent of RP-5. The following sections present the proposed systems for conveying the flows upstream to RP-5.

4.1.2.1 Butterfield Ranch Force Main

The City of Chino Hills owns and operates the Butterfield Ranch Lift Station, with sewage pumps and 10-in-diameter force main that currently transport flows to RP-2. The Butterfield Ranch Lift Station will require an upgrade of the existing pumps to overcome the additional head losses and convey the flow to RP-5. The existing 10-in-diameter force main to RP-2 may be reused; however, since this pipeline terminates at RP-2, a new 10-in-diameter force main extension will need to be constructed along El Prado Road and Mountain Avenue. The 10-in-diameter force main will connect to a new 12-in force main on Mountain Avenue and will be conveyed to RP-5 via the new Mountain Avenue Lift Station at the RP-5 solids handling facility (SHF) site. These proposed modifications in the collection system are illustrated below in Figure 4-2.

4.1.2.2 CIW Sewer

The City of Chino is planning to construct a new lift station to convey flows from CIW to RP-5. The new lift station will be located next to the existing Prado chlorination facility. The golf course clubhouse flows will be discharged to a new sealed double-wall underground fiberglass reinforced plastic storage tank. The tank will have anchor straps that can either attach to a deadmen anchoring system or an anchor pad. Anchoring the system prevents the tank from floating during flood events. The sewage accumulated in the tank can be removed by periodic pumping with vacuum trucks. A vacuum system conveying the golf course flows through a pipeline under negative pressure to a vacuum pumping station above the flood inundation area was also considered. However, the length of the vacuum pipeline and the static head required deemed the system as hydraulically infeasible.

4.1.2.3 Mountain Avenue Sewer

The flows from the Mountain Avenue Sewer will be intercepted and discharge to the wet well of a new lift station. The new lift station will be located in an area meeting the following criteria: proximity to the Mountain Avenue Sewer; land owned by the IEUA; ease of egress and ingress for maintenance vehicles; and proximity to an interceptor upstream to RP-5.

While odors are not anticipated to be an issue, the potential location will not be near a public space where potential odors will be a nuisance to the public. The new lift station will also include security, drainage, and site improvement measures.

4.1.3 Mountain Avenue Lift Station Location

The RP-5 SHF is located alongside Mountain Avenue and the existing 24-in-diameter Mountain Avenue Interceptor Sewer. The SHF is located at or above the flood inundation level of 566 and is owned by the IEUA. Space is currently available for a new lift station wet well, valve/meter vault, and pathway for maintenance vehicles in the southeast corner of the SHF, northeast to the existing stormwater pond and away from existing operations.

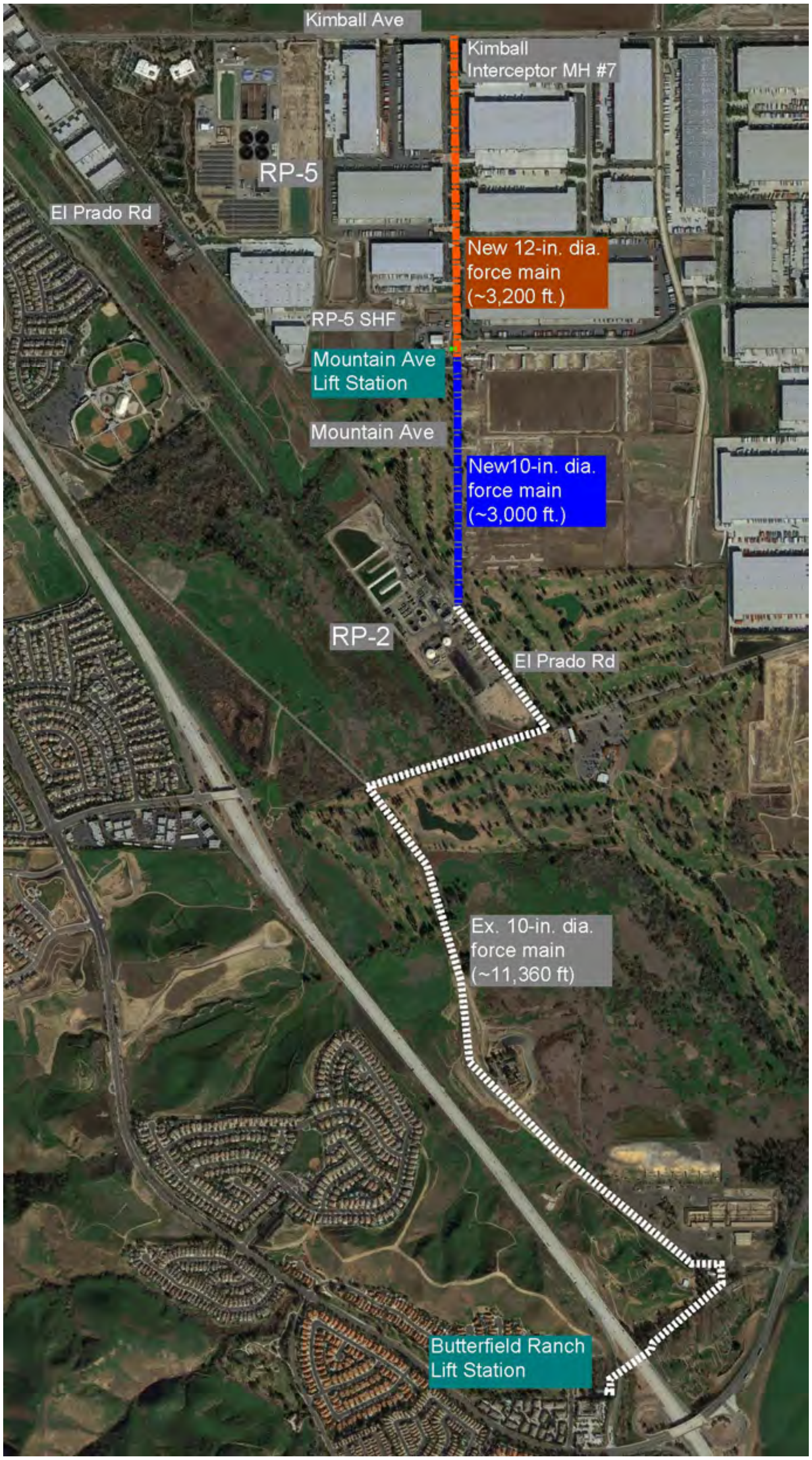


Figure 4-2: Proposed Force Main System

The lift station will be located in an area that would cause less disturbance to current IEUA onsite operations and be accessible through a new gate on Mountain Avenue separate from the existing main entrance of the site. The new lift station space will be separated from the rest of the SHF with a new fence. Trucks will not need to use the existing main entrance to SHF to perform routine maintenance. A secondary gate will be provided, however, on the new fence for access to the SHF facilities by operations staff. The maintenance trucks are assumed to be single unit trucks, having an overall length of 30 feet (ft) and minimum design turning radius of 42 ft[1].

The existing site has unpaved ground surface and will require approximately 4,200 square feet (sf) of asphalt pavement for all weather access. The site is adjacent to Mountain Avenue and new openings can be created in the existing perimeter chain linked fence to provide new gates for access by maintenance vehicles and a new block wall will be constructed in-between the entrance and exit gates to conceal the lift station operations from public viewing. Because the new entrance and exit pathways will cross over the existing sidewalk and planters, the sidewalk and vegetation will need to be restored. A preliminary layout for the new lift station is shown in Figure 4-3 below.

4.1.4 Mountain Avenue Lift Station Design Criteria

4.1.4.1 Lift Station Capacity

The Agency has forecasted that the average flows of the new Mountain Avenue Lift Station will be about 0.3 million gallons per day (mgd) from present day to year 2040, and 0.4 mgd from 2040 to 2060. Using a peaking factor of 2.0, the design flow for this lift station is 0.8 mgd or 560 gallons per minute (gpm). Therefore, two pumps (one duty and one standby) sized at 0.8 mgd (560 gpm) each will be provided to meet peak flows.

4.1.4.2 Influent Gravity Sewer

The invert elevation of the Mountain Avenue sewer manhole ("Manhole No. 8") at Kimball Avenue is 559.96[2]. The invert elevation of the Mountain Avenue sewer near SHF was assumed to be 556.75, with the assumption that the Mountain Avenue sewer shares the same slope as the Mountain Avenue.

The sewage flows in the Mountain Avenue interceptor sewer will be intercepted with a new diversion manhole. With a minimum slope of 0.0056 ft/ft and pipe diameter of 10 in, the velocity of sewage flowing full through the pipe will be 3.0 ft/second (s). To reach the new wet well, the pipeline will be approximately 40 ft in length and enter at an invert elevation of 556.53.

4.1.4.3 Sewage Force Main

The lift station will discharge the sewage flows to an existing manhole on the Kimball Avenue Interceptor sewer, approximately 3,200 ft north on Kimball Avenue, through a new force main. The new force main is expected to have a 12-in diameter, based on conveyance of the additional discharge flows of up to 1,100 gpm currently projected for the Butterfield Ranch Lift Station. The proposed force main system is shown above in Figure 4-2.

---

[1] AASHTO, *A Policy on Geometric Design of Highways and Streets, 6th Edition, 2011*

[2] Project No. EN97004-3 Phase II record drawings.

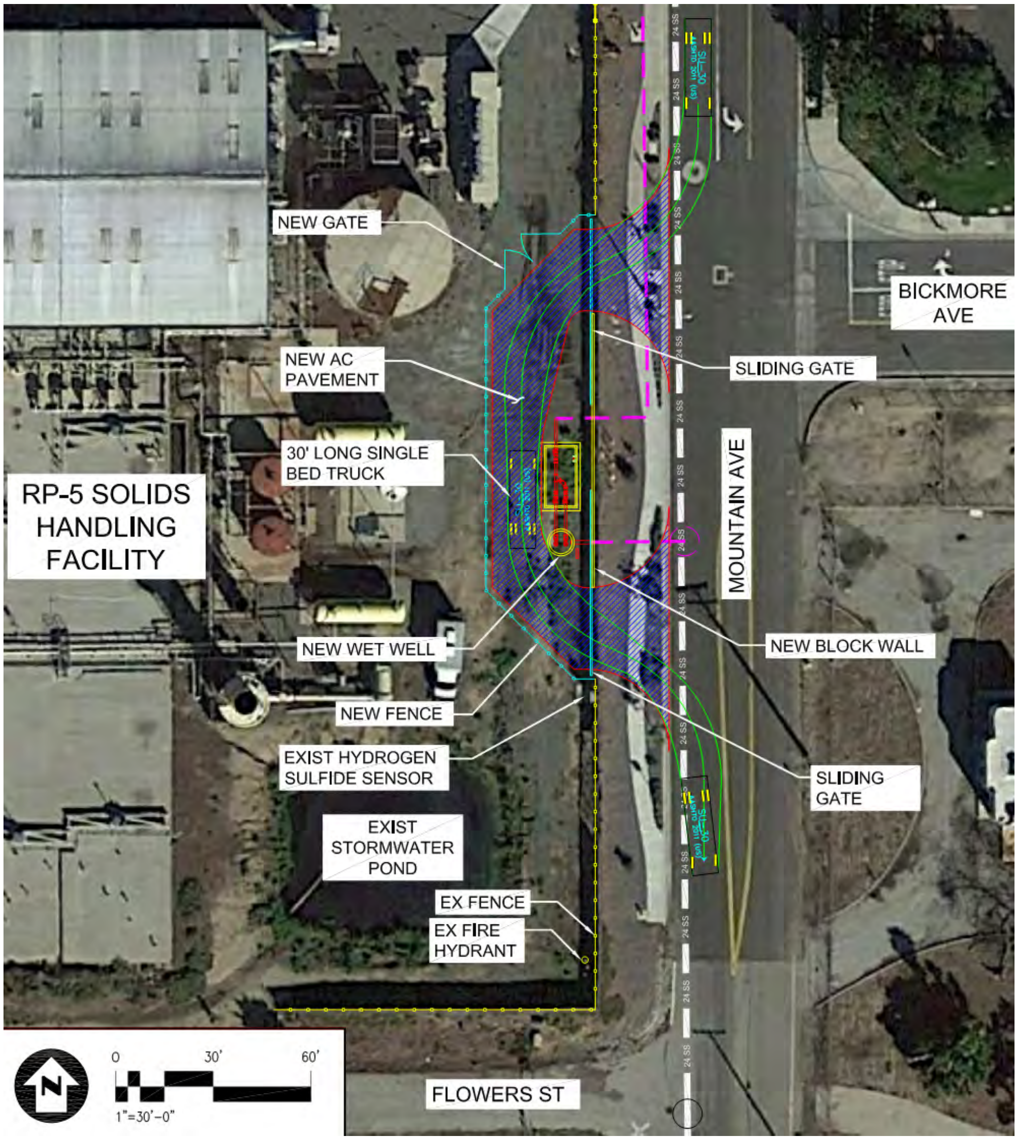


Figure 4-3: New Lift Station Layout

4.1.4.4 Pump Sizing

The invert of the existing manhole on the Kimball Interceptor is 559.96. Assuming the interceptor is 90% full, the water level elevation will be 564.91. If the low water level at the wet well is 550.5, the static head the pumps will need to overcome will be 14.4 ft. The head loss at 560 gpm through the 8-in force main will be approximately 21.4 ft. Therefore, the total dynamic head (TDH) of each pump will be approximately 36 ft. The pumps will be constant speed driven with 10-horsepower (hp) motors. Figure 4-4 shows the pump-system curves at different flow rates.

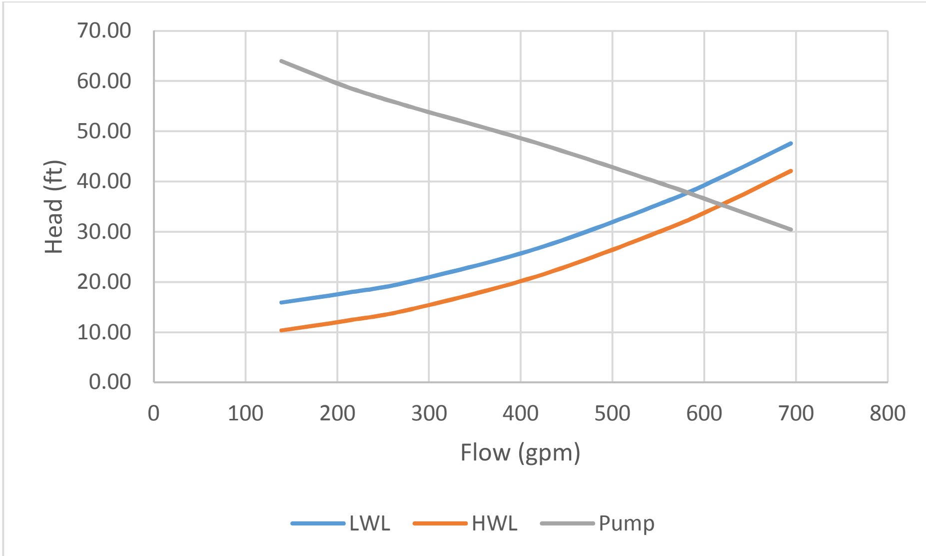


Figure 4-4: Pump System Curve

4.1.4.5 Wet Well

The wet well will have an inner diameter of 8 ft and be constructed of either concrete or fiberglass material. The wet well will contain two rail-mounted submersible pumps. The lead pump will stop at an elevation no less than the minimum submergence level per the selected pump's specifications. The bottom of the wet well elevation will be set to limit the motor to maximum six starts per hour. Preliminary pump operating elevations are presented in Table 4-1.

Table 4-1: Preliminary Pump Operating Elevations

Parameter	Elevation (ft)
High-High Water Level (HHWL)	556.0
High Water Level (HWL)	555.5
Lead Pump Start	555.0
Lead Pump Stop	551.0
Low Water Level (LWL)	550.5

4.1.4.6 Valve/Meter Vault and Appurtenances

Each pump will discharge into a respective 8-in-diameter lateral pipe, which will enter a valve/meter vault containing check valves, isolation valves, and a flow meter (Figure 4-5). One of the 8-in discharge pipelines will include a quick disconnect coupling for a bypass connection to a portable pump in the event of pump failure.

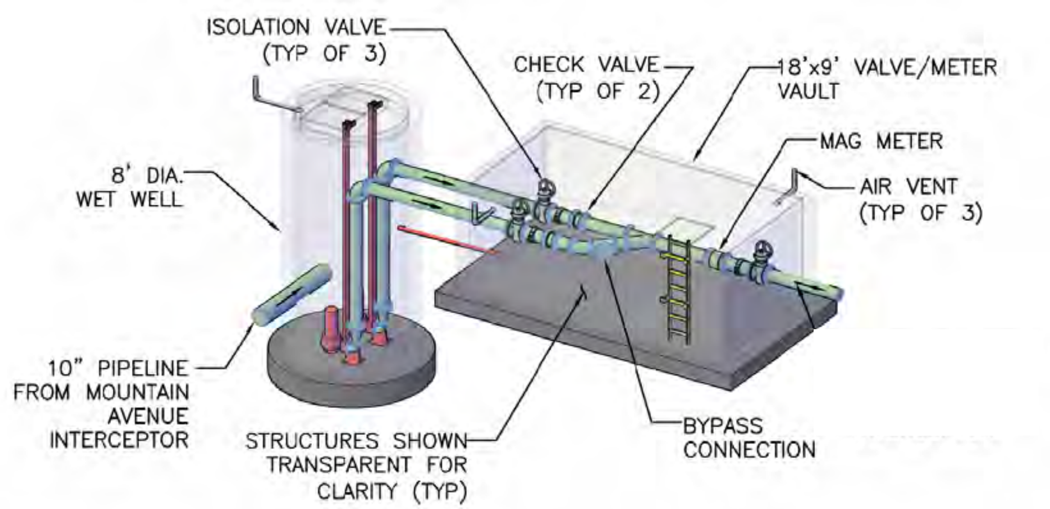


Figure 4-5: Pump Wet Well and Valve/Meter Vault

The wet well and valve vault will be provided with ventilation pipes. Additionally, a 2-in-diameter drain will be provided between the valve/meter vault and wet well to drain any water that may enter the vault. A plant water line will be provided for a hose bibb connection to allow for wash down activities. An above-ground control panel in a NEMA-4 enclosure will be provided along with electrical conduits for power and signaling. The pumps will be designed to alternate daily to extend the life of the priming equipment.

In-line emergency storage of 60 minutes at peak flow (or 4,500 cubic feet [ft^3]) can be provided in the 24-in-diameter Mountain Avenue Interceptor sewer that connects to the 8-in-diameter influent pipeline. The MCC will be equipped with a manual transfer switch and connectors suitable for connection to a potable emergency generator in the event of a power failure. Alternatively, by connecting to the provided quick disconnect coupling, a portable pump can pump flows in the wet well to the force main and bypass the submersible pumps should it be required.

4.1.5 Butterfield Ranch Lift Station

4.1.5.1 Background

The Butterfield Ranch Lift Station, located at 14754 Brookwood Lane, Chino Hills, consisting of four self-priming centrifugal pumps. The lift station receives flow through a 15-in-diameter gravity sewer from the east. The 15-in-diameter sewer connects to a manhole on site prior to entering from a manhole on site. After the manhole, the sewage flow goes through an in-channel comminutor before entering the wet well. The design criteria[3] for the lift station are shown in **Table 4-2**.

[3] "Improvement plans for the construction of the Butterfield Sewage Lift Station," record drawings prepared by Hall & Foreman, Inc. for the Butterfield Ranch Company, October 30, 1987.

Table 4-2: Pump Station Design Flows

Design Flow	Flow Rate
1. Peak sewage flow	1,064 gpm
2. Average sewage flow	368 gpm
3. Minimum pump station flow	400 gpm
4. Maximum pump station flow	1,064 gpm

The Butterfield Ranch Lift Station contains four self-priming centrifugal pumps (Table 4-3) located on the ground floor in the pump room.

Table 4-3: Existing Pumps at the Butterfield Ranch Lift Station

Pump No.	Service	Flow Rate (gpm)	TDH (ft)	Motor Size (hp)
P1	Raw sewage	1,080	90	60
P2	Raw sewage	1,080	90	60
P3	Raw sewage	750	50	20
P4	Raw sewage	750	50	20

The lift station has a 200-kilowatt (kW) diesel generator and a 500-gallon (gal) fuel tank to provide standby power in case of a power failure.

In order to bypass the RP-2 Lift Station and pump sewage flows to RP-5, the force main will require to be extended (as described previously) and the pumps will require upgrade to overcome the additional head in the new force main system.

4.1.5.2 Design Criteria

The design flow for the upgraded lift station will remain the same as the existing lift station as listed in Table 4-2. The lift station will be capable of pumping incoming flows between the minimum pumping station flow of 400 gpm and the maximum pumping station flow of 1,064 gpm. The new pumps will have a design capacity of 1,065 gpm to meet the peak flow, with three 355-gpm duty pumps and a 355-gpm standby pump having a 40-hp motor for each pump.

In order to overcome the additional friction losses associated with the extended force main, the existing single-stage self-priming pumps (Gorman Rupp Models T6A3-B and T8A3-B) will need to be replaced with new pumps capable of handing the additional head. However, a single-stage self-priming pump will not be capable of handing the additional head and a two-stage self-priming replacement pump that meets the design condition will require an additional 17 in of vertical space compared to the existing pumps that may not be able to be accommodated by the existing discharge piping and valves connecting to the pumps due to existing piping and site constraints.

An alternative to the self-priming pumps would be the installation of four submersible pumps in the existing wet well to replace the existing suction pipes and above-floor self-priming pumps. The pump-system curves for the submersible pumps that could be used to replace the existing pumps are shown in Figure 4-6.

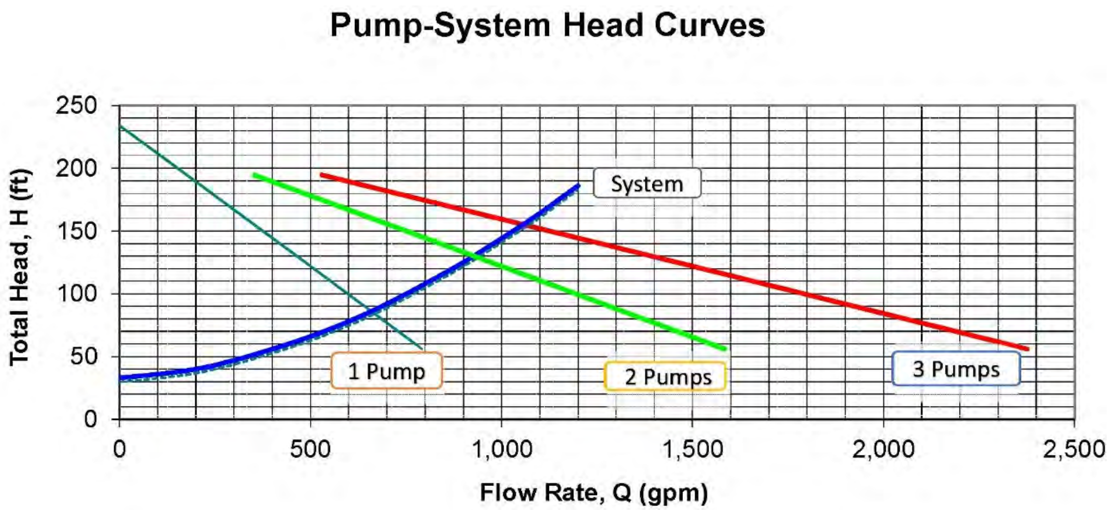


Figure 4-6: Butterfield Lift Station Pump and System Curves (Xylem NP 3171 SH 3~277)

The upgrade of the lift station will meet the following criteria:

- Capable of pump flows to the Kimball Interceptor and meet the minimum flow of 400 gpm and the peak flow of 1,064 gpm.
- Capable of pumping the peak flow with three duty pumps and one standby pump.
- Pumps suitable for raw wastewater.
- Capable of operating the pumps within high efficiency range on the pump curve and within the pump manufacturer's recommended operating range.
- Use of premium efficiency motors.
- Not relying on self-priming to start pumps.
- Upsized diesel engine generator and fuel tank to provide the same duration of standby power as the existing unit.
- New valves, piping and accessories as required for the installation of the new pumps.
- Modifications to the motor control center (MCC) and electrical equipment as required for the new pumps and motors.
- Provisions for bypass pumping to maintain continuous operation of the lift station during construction.

4.1.6 Preliminary Cost Estimate

4.1.6.1 Basis of Cost Estimate

The costs presented herein reflect an *Engineering News-Record* Construction Cost Index of 11555 (*ENR* CCI – Los Angeles, December 2016). The estimate was developed using historical costs from recent projects, proprietary cost data, and vendor quote information. The cost includes major project elements plus indirect costs (markups) associated with completion of the estimate. Project markups include contractor overhead and profit, contingency, and escalation to midpoint of construction. The contingency provides for unknown construction conditions and final design completion variations.

The construction cost estimate is referred to as Class 3 – "Budget Level Estimate" based on the cost estimate classifications by the American Association of Cost Engineers (AACE) International[4]. The final construction costs will depend on final project scope, actual labor and material costs, market conditions, actual site conditions, implementation schedule and other factors that may impact the project costs.

4.1.6.2 Preliminary Cost Estimates

Table 4-4 provides the estimated capital costs of the lift stations and force mains.

Table 4-4: Estimated Capital Costs

	Item	Estimated Cost
1	**Mountain Avenue Lift Station**	$319,000
2	**12-in force main (3,200 ft)**	$768,000
3	**Chino Hills Butterfield Ranch Lift Station Improvements**	$300,000
4	**10-in force main to Mountain Ave. Lift Station**	$600,000
8	**Subtotal 1**	$1,987,000
9	15% Overhead and Profit	$298,000
10	8% Inflation	$159,000
11	4% Bonds and Insurances	$79,000
12	30% Contingency	$757,000
13	**Subtotal 2**	$3,280,000
14	Design and Project Administration (20%)	$656,000
15	**Total Construction Cost** (Sum of Items 13 and 14)	**$3,936,000**

4.1.7 Conclusions and Recommendations

The new Mountain Avenue Lift Station will be located in an unoccupied area southeast of the SHF. The construction of the new lift station, force mains, and Butterfield Ranch Lift Station improvements should be completed at least 6 months prior to the decommissioning of the existing RP-2 Lift Station.

[4] AACE Recommended Practice No. 18R-97, "Cost Estimate Classification System – as applied in Engineering, Procurement, and Construction for the Process Industries," Rev. 3/1/2016.

Inland Empire Utilities Agency
A MUNICIPAL WATER DISTRICT

Evaluation of the Relocation of the IEBL Discharge Station

Predesign Report
Volume III, Chapter 5

February 28, 2017

submitted by

PARSONS

in association with

Brown AND Caldwell

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

THIS PAGE INTENTIONALLY LEFT BLANK.

CHAPTER 5: EVALUATION OF THE RELOCATION OF IEBL DISCHARGE STATION

5.1 INLAND EMPIRE BRINE LINE (IEBL) DISCHARGE STATION

5.1.1 Background

In accordance with the easement renewal for the right-of-way for Regional Water Recycling Plant #2 (RP-2) granted by the United States Army Corps of Engineers (USACE) that extended the easement term from May 9, 2010 to May 8, 2035, IEUA is required to remove all RP-2 facilities, which includes the Inland Empire Brine Line (IEBL) Discharge Station at RP-2, which is one of the four waste collection stations on the IEBL system. The IEBL Discharge Station, shown in Figure 5-1 below, is a septage receiving station that receives trucked liquid waste from permitted haulers and discharges the waste to the 27-inch (in) diameter IEBL (previously known as the Santa Ana Regional Interceptor [SARI]) on El Prado Road. The IEBL is owned by the Santa Ana Watershed Project Authority (SAWPA) while IEUA owns and maintains the IEBL Discharge Station and the 8-in-diameter sewer lateral connecting the Discharge Station to the IEBL. The IEBL transports salty wastewater to the Orange County Sanitation District's wastewater treatment facility (Plant 2) in Huntington Beach.

The IEBL Discharge Station is located near RP-2 and is below the 566 elevation associated with the Prado Dam inundation area. Therefore, under the agreement established with the USACE, IEUA is required to decommission, demolish, and remove the IEBL discharge station and 8-in sewer lateral and restore the site and utilities. The decommissioning of the IEBL discharge station is discussed in Chapter 3 of Volume III.

Figure 5-1: Existing IEBL Discharge Station

The IEBL Discharge Station was constructed in 2010 and has a dump station manhole, which receives septage from two septage receiving stations, and two catch basins that capture any stormwater and spray down waste. Each septage receiving station includes a quick disconnect coupling where hauling trucks can connect to and send septage through. The incoming septage is analyzed for pH, temperature, conductivity, and sulfide—ensuring the waste does not surpass the IEBL disposal limits. A magnetic flow meter and automatic sampler are also provided in the station. As currently configured, the dump station manhole sends septage through an 8-in-diameter pipeline to a previously constructed dump station, which then sends septage through an 8-in-diameter pipeline to the 27-in-diameter IEBL. In this design, most of the septage is contained and odors are limited from escaping into the atmosphere.

The IEBL Discharge Station has restricted access where only permitted waste haulers can enter the fenced area. Several instrumentation and electrical equipment are provided at the existing IEBL Discharge Station as listed below:

- (4) Proximity Card Readers
- (4) Gate Controllers, (4) Gate Actuators with (3) Detector Loops each
- (2) Flood Light/Camera supported on a Pole
- Modular Enclosure: Lighting Panel, Supervisory Control and Data Acquisition (SCADA) Panel, Security Panel, and Irrigation Controller

Two of the proximity card readers are provided outside of the fence, where the trucks enter the station while the other two are featured inside of the fence, where the trucks exit the station. Signals from the card readers will be sent to the gate controllers, which together with the detector loops, control the opening and closing of the gates. A pair of flood lights and cameras are also included at the station to enforce site security. The panels in the modular enclosure receive and transmit signals to the communication panel located in the RP-2 plant control station.

5.1.2 Design Objectives

To replace the existing IEBL Discharge station, a new IEBL Discharge Station will be constructed in an area outside of the 566-foot (ft) Prado Dam inundation area. The new discharge station will have a similar configuration and design as the existing. Because the existing system was constructed in 2010, less than 7 years ago, the two existing septage receiving stations could be relocated to the new discharge station. Based upon record drawings, the hauling trucks were assumed to be large semitrailers, WB-50, having an overall length of 55 feet[1], similar to the trucks currently being used by the waste haulers.

Considerations for locating the site for the new discharge station included the following: proximity to the IEBL; truck accessibility and ease of egress and ingress; available IEUA properties, and existing utilities. Utilities that will be required include utility water for wash down and electrical to power the septage receiving stations and, where applicable, surveillance systems. The electrical and instrumentation equipment will also send and transmit signals to an IEBL's operations center; therefore, potential locations in proximity to IEUA's water reclamation facilities adjacent to the IEBL (e.g., RP-5 and Carbon Canyon Water Recycling Facility [CCWRF]) were evaluated.

[1] AASHTO, *A Policy on Geometric Design of Highways and Streets, 6th Edition, 2011*

5.1.3 Alternatives for the Relocation of IEBL Discharge Station

Initially, eight locations were considered for the new IEBL Discharge station. These options were as follows:

A. Chino Creek Wetlands and Education Park where trucks enter from El Prado Road and exit to Kimball Avenue
B. West of the Chino Creek Wetlands and Education Park where trucks enter and exit from and to El Prado Road
C. South of the Chlorine Contact Tanks at CCWRF where trucks enter and exit through a new opening to and from Telegraph Avenue
D. North of the Solar Panels at CCWRF where trucks enter and exit through the existing entrance off Telegraph Avenue
E. West of Existing Solar Panels at RP-5.
F. West of the Headworks at CCWRF where trucks enter through the existing entrance off Telegraph Avenue and exit through a new opening onto Chino Hills Parkway
G. Northeast corner of RP-5 near the entrance off Kimball Avenue.
H. West of the RP-5 Solids Handling Facility where trucks will enter and exit through existing openings off Mountain Avenue.

Options A, B, C, D, and E were considered infeasible; evaluation of these options including concerns and design constraints are presented in Appendix A. Options F, G, and H are considered as feasible alternatives and are presented in the sections below and renamed as Alternatives 1, 2 and 3.

5.1.3.1 Alternative 1: Located West of the Headworks at CCWRF

Alternative 1 has the new IEBL Discharge Station located on the north side of the CCWRF, west to the Headworks. Under this alternative, incoming hauling trucks will enter CCWRF through the existing entrance off of Telephone Avenue. Upon entering the plant, the trucks will follow the pathways shown on Figure 5-2.

Figure 5-2: Alternative 1 Overall Layout

The trucks will be directed to the new discharge station located west of the existing headworks. The existing site contains trees and soil, the former which will need to be uprooted and removed while the latter will be paved with about 13,000 square feet (ft^2) of asphalt concrete. Between the headworks and the boundary wall, around 65 ft is available for the construction of a new discharge station as shown on Figure 5-3.

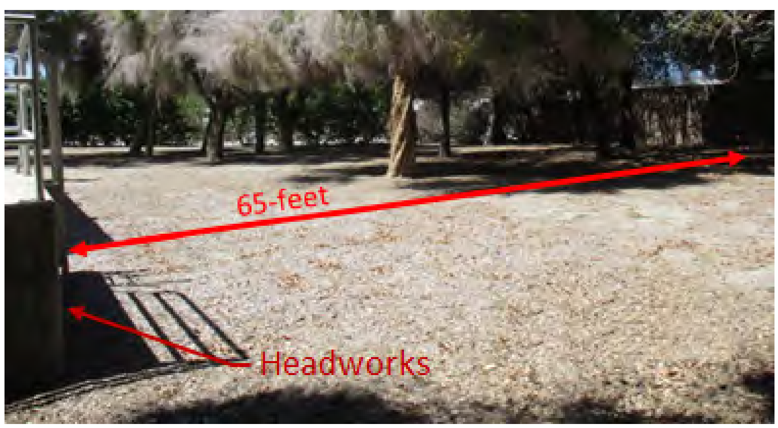


Figure 5-3: Available Space West of the CCWRF Headworks

To exit, the trucks will pass through a new slide gate, where a pair of proximity card readers will be provided along with two gate controllers and two gate actuators with detector loops. Upon passing through the slide gate, the trucks will exit the premises through a new opening to Chino Hills Parkway. The new opening (Figure 5-4) will require part of the existing CMU wall be demolished. While not recommended, the hauling trucks could also enter the discharge station through this new opening. Therefore, a pair of proximity card readers will be provided on the street side of the slide gate. Because the new discharge station will be within the CCWRF, security measures such as a fence and security camera are not required. Signals will still need to be transmitted to and from the plant control station to monitor the dumping activities at the new discharge station.

Figure 5.4: Proposed Opening for Exiting or Entering

A new 80-ft-long, 8-in-diameter sewer pipeline will be constructed to connect the new dump station manhole to a new manhole (Figure 5-5). The new manhole will connect to an existing manhole on the IEBL with a new 40-ft-long, 8-in-diameter sewer pipeline. The existing IEBL is located approximately 25 ft west of the headworks. The new discharge station will also include connections to existing recycled water pipelines for wash down activities and a power source for the septage receiving stations and entering/exiting gate.

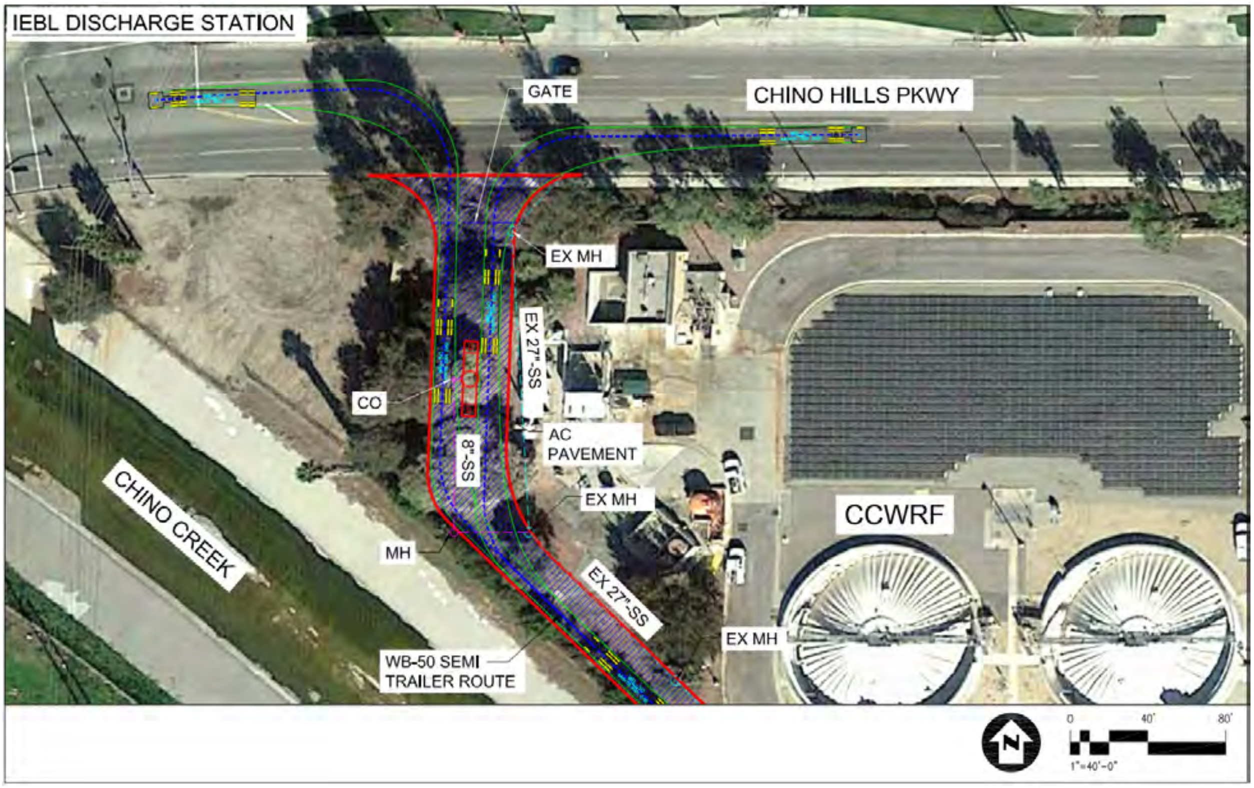


Figure 5-5: Alternative 1 Enlarged Layout

5.1.3.2 Alternative 2: Located Northeast of RP-5

Alternative 2 locates the new IEBL Discharge Station at the northeast corner of RP-5, near the main entrance to RP-5. Truck haulers would enter off Kimball Avenue through the existing driveway (see Figure 5-6). Instead of entering the RP-5 facility, however, trucks will enter through a new opening in the existing west CMU wall.

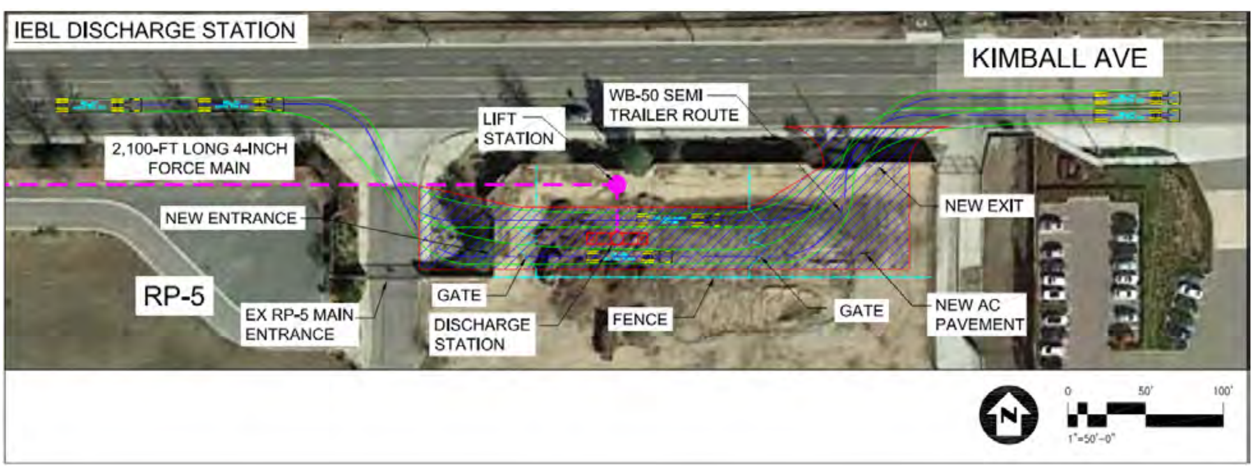


Figure 5-6: Alternative 2 Enlarged Lay

Approximately 17,000 ft^2 of asphalt concrete pavement will be laid down to construct this new pathway. To exit, a new opening will be created in the existing north CMU wall. Trucks leaving the discharge station will only be allowed to turn right due to safety concerns and the limited turning radii. Enough space has been provided for trucks at the entrance in the event that both septage receiving stations are occupied. Even though adequate space and turning radii have been provided, coordination with City of Chino will occur during the design phase to confirm that this configuration meets City standards. It is likely that a dedicated right-turn approach lane encroaching into the RP-5 north property may be required to stage incoming waste hauling trucks and minimize impact on the traffic on Kimball Avenue.

To isolate the discharge station from RP-5, new security fencing and gates will be constructed along with a security camera. Both the entrance and exit gates will have two gate controllers and two gate actuators along with detector loops. Signals will be transmitted to and from the RP-5 plant control station to monitor the dumping events at the new discharge station.

Because the new discharge station is approximately 2,400 ft away from the IEBL, the new dump station manhole will connect to a new lift station, which will be required to avoid the existing underground utilities. The new lift station will have a pair of submersible pumps that will send flows through a 2,100-ft-long, 4-in-diameter force main to a new manhole (Figure 5-7). The new manhole will connect to an existing manhole on the IEBL with a new 300-ft-long, 8-in-diameter gravity pipeline. The new discharge station will also include connections to recycled water pipelines for wash down activities and a power source for the septage receiving stations and entering and exiting gates.

Figure 5-7: Alternative 2 Overall Layout

5.1.3.3 Alternative 3: Located West of the RP-5 Solids Handling Facility

Alternative 3 presents a new discharge station at the RP-5 Solids Handling Facility (SHF). Trucks will enter and exit through an existing gate off Mountain Avenue. As shown in Figure 5-8, the trucks will enter the new discharge station that will be fenced off from the rest of the RP-5 SHF. Gates with gate controllers and gate actuators along with detector loops will be constructed at both the entrance and exit of the discharge station. Security cameras will also be constructed as a security measure. Signals will be transmitted to and from the RP-5 plant control station to monitor the dumping events at the new discharge station.

Approximately 35,500 ft^2 of asphalt concrete will be constructed for the new pathway. The new discharge station will also include connections to recycled water pipelines for wash down activities and a power source for the septage receiving stations and entering/exiting gate.

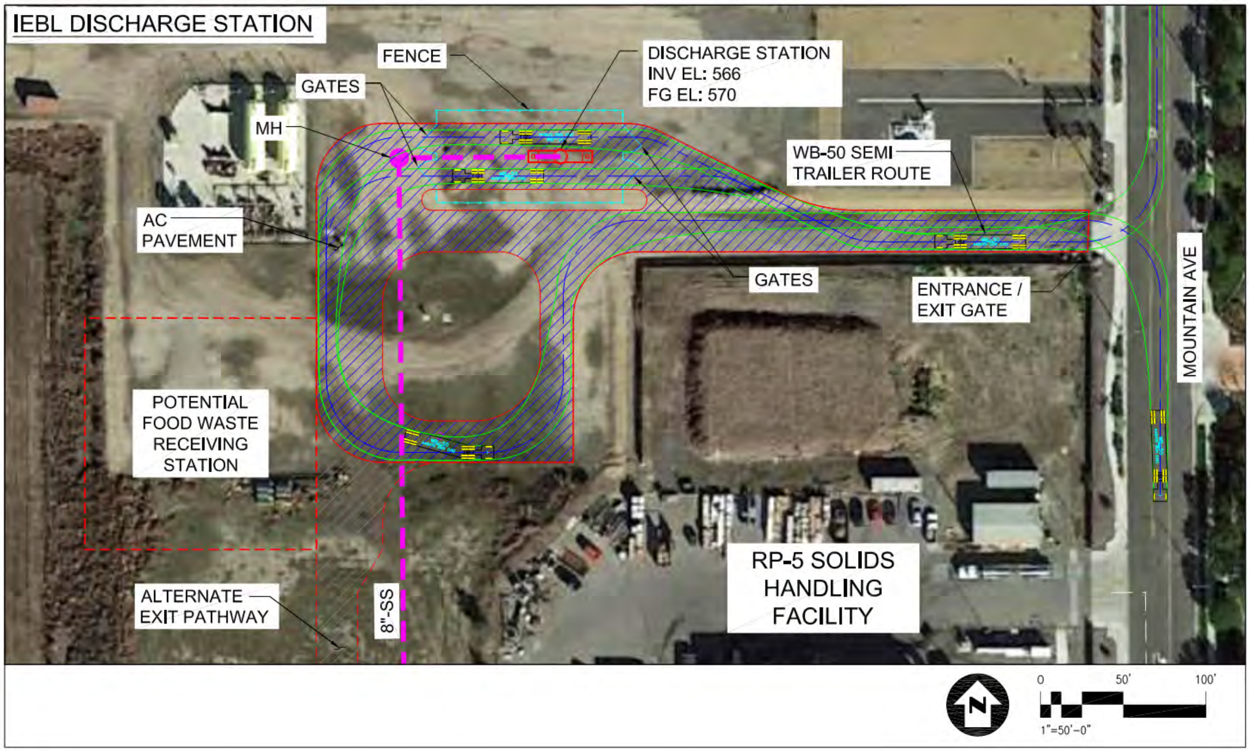


Figure 5-8: Alternative 3 Enlarged Layout

The dump station manhole will send the waste through a 100-ft-long, 8-in-diameter sewer pipeline to a new manhole (Figure 5-9). From this new manhole, another 8-in-diameter pipeline measuring 650 ft in length will send the flows to another new manhole located on Flowers Street. This new manhole will connect the new 8-in-diameter pipeline to the existing 8-in-diameter pipeline that connects to the IEBL.

Because the discharge station is located to the north of the Solids Handling Facility (SHF), space would be available for a potential food waste receiving station. In addition, a secondary exit pathway could be constructed for trucks to leave the site through Flowers Street except during a flood event. This secondary pathway will require extensive re-grading, however, as the grade separation between SHF and Flowers Street is approximately 5 ft to 6 ft and 13,500 ft^2 of additional asphalt concrete pavement.

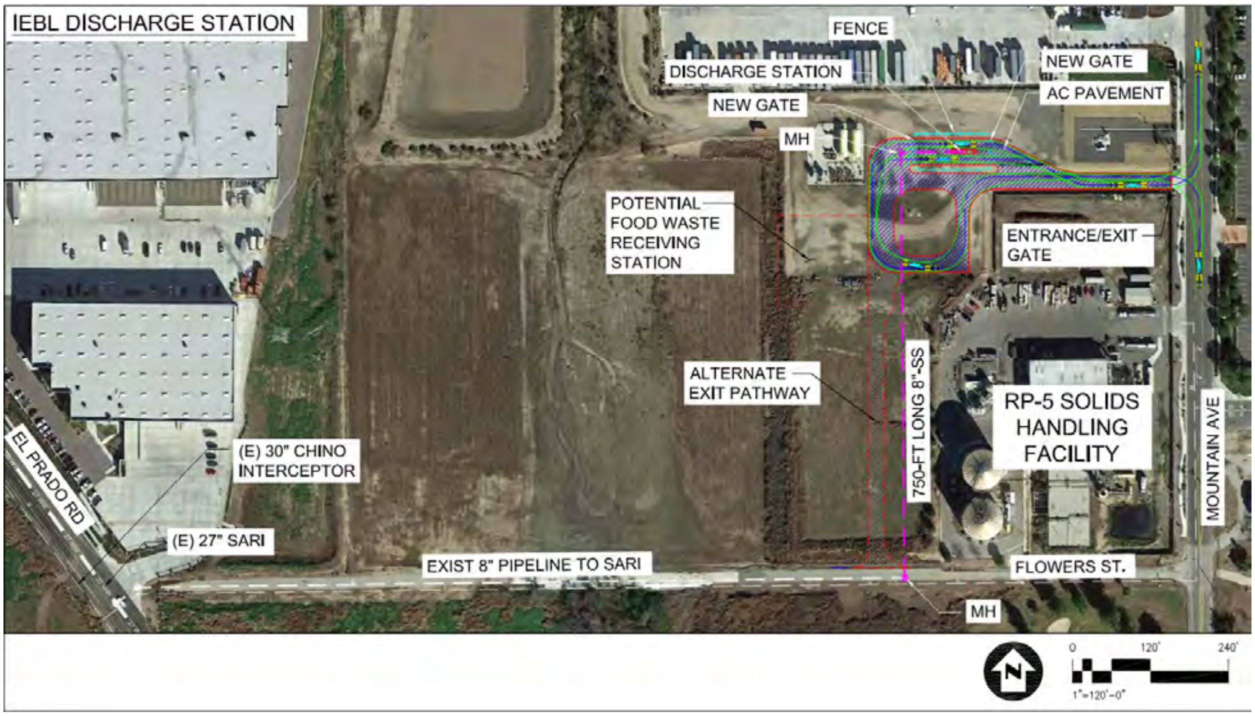


Figure 5-9: Alternative 3 Overall Layout

Locating the discharge station west of the SHF was also evaluated, where trucks will enter from Mountain Avenue and exit onto Flower Street (Figure 5-10). As mentioned earlier, exiting onto Flower Street will require extensive regarding due to the elevation difference between SHF and Flowers Street. A secondary exit pathway will be provided that can be used during a flood event; however, IEUA staff has expressed a preference for the private haulers not to enter the SHF on a regular basis. In this configuration, the septage receiving stations were arranged in linear fashion instead of side-by-side. Approximately 32,000 ft^2 of asphalt concrete pavement will be required. Because the Discharge Station is closer to the existing 8-in pipeline, only around 500 ft of 8-in gravity sewer pipeline will be required along with the two new manholes.

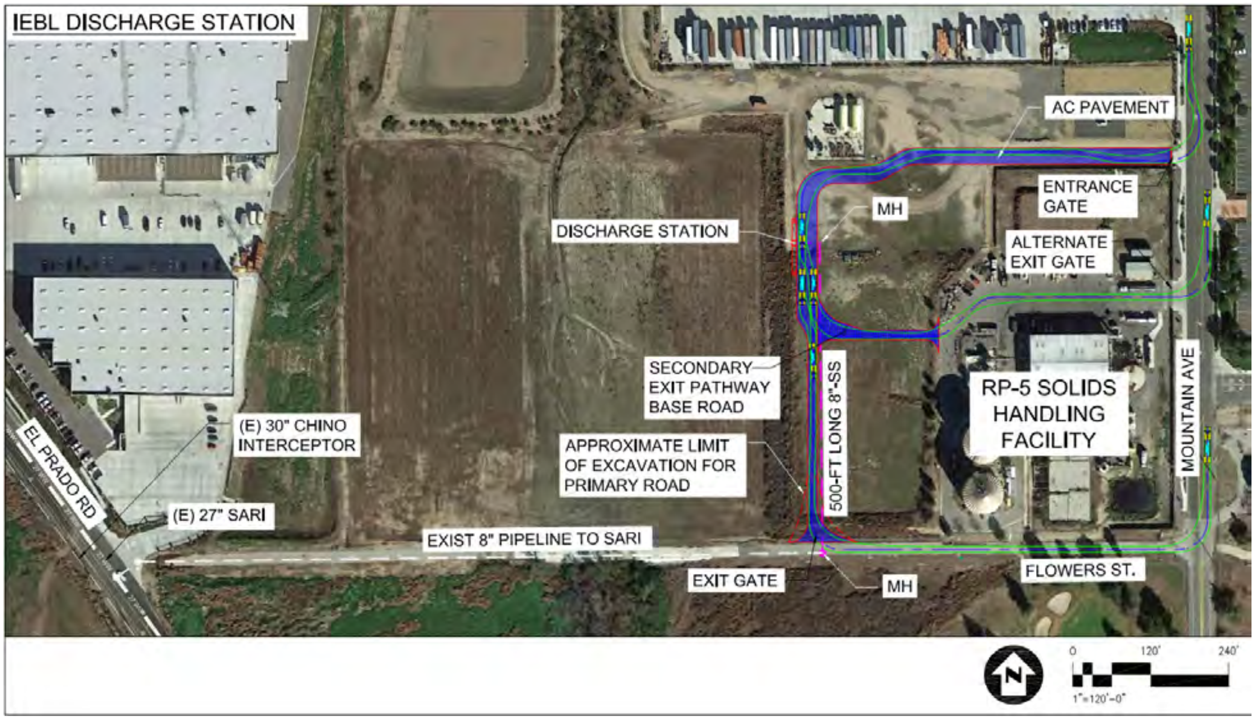


Figure 5-10: Alternative Layout to Alternative 3

Despite the savings in pipe length, locating the IEBL discharge station north of the SHF is preferable because less asphalt concrete pavement and regrading will be required for trucks to exit the premise. Therefore, the layout shown on Figures 5-9 and 5-10 will be considered in the business case evaluations.

5.1.4 Business Case Evaluation (BCE)

5.1.4.1 Alternatives Comparison

The advantages and disadvantages of the three alternatives are presented in Table 5-1.

Table 5-1: Comparison of Alternatives for the Relocation of the IEBL Discharge Station

Alternative	Advantages	Disadvantages
Alternative 1: West of CCWRF Headworks	Located on existing IEUA property	Requiring a new exit gate on Chino Hills Pkwy and demolishing at existing perimeter wall
	Utilizing unoccupied space at CCWRF	Requiring trees to be uprooted and re-grading
	Close proximity to IEBL	Increased truck access through busy Chino Hills Pkwy
	—	Exiting through new opening near the existing intersection On Chino Hills Pkwy may pose traffic safety concerns
	—	Waste hauler personnel will enter plant
Alternative 2: Northeast of RP-5	Located on existing IEUA property	Likely requires a lift station
	Utilizing unoccupied space at RP-5	Requiring extensive piping to reach IEBL
	Relative low impact to RP-5 operations	Increased traffic at entrance from Kimball Ave
	Waste hauler personnel will not enter plant	Egress restricted to right turn only

Alternative	Advantages	Disadvantages
		City of Chino may raise additional requirements
Alternative 3: North of SHF	Located on existing IEUA property	Shared pathway with other trucks
	Utilizing unoccupied space at RP-5	Occupying extensive space that could have been used for other purposes
	Relative low impact to RP-5 operations	—
	Using existing 8-in-diameter pipeline to IEBL	—
	Waste hauler personnel will not enter plant	—

5.1.4.2 Basis of Cost Estimate

The costs presented herein reflect an *Engineering News-Record* Construction Cost Index of 11555 (*ENR* CCI – Los Angeles, December 2016). The estimate was developed using historical costs from recent projects, proprietary cost data, and vendor quote information. The cost includes major project elements plus indirect costs (markups) associated with completion of the estimate. Project markups include contractor overhead and profit, contingency, and escalation to midpoint of construction. The contingency provides for unknown construction conditions and final design completion variations.

The construction cost estimate is referred to as Class 3 – "Budget Level Estimate" based on the cost estimate classifications by the American Association of Cost Engineers (AACE) International[2]. The final construction costs will depend on final project scope, actual labor and material costs, market conditions, actual site conditions, implementation schedule and other factors that may impact the project costs.

5.1.4.3 Preliminary Cost Estimates

Table 5-2 provides the estimated capital costs of the three alternatives for the relocated IEBL Discharge station.

Table 5-2: Estimated Capital Costs

	Item	Alternative 1 West of CCWRF	Alternative 2 Northeast of RP-5	Alternative 3 North of SHF
1	Yard Piping	$23,000	$260,000	$144,000
2	Structures	$33,500	$36,000	$36,000
3	Civil	$87,000	$89,000	$186,000
4	Septage Station Relocation	$10,000	$10,000	$10,000
5	Solar Panel Relocation	-	-	-
6	Site Security Improvements	$11,500	$21,000	$17,000
7	Lift Station	-	$113,000	-

[2] AACE Recommended Practice No. 18R-97, "Cost Estimate Classification System – as applied in Engineering, Procurement, and Construction for the Process Industries," Rev. 3/1/2016.

	Item	Alternative 1 West of CCWRF	Alternative 2 Northeast of RP-5	Alternative 3 North of SHF
8	Sales Tax (8.0%)	$4,400	$17,000	$11,000
9	**Total Direct Cost**	$170,000	$546,000	$404,000
10	Overhead and Profit (15%)	$25,500	$81,900	$60,600
11	Inflation (8%)	$13,600	$43,700	$32,300
12	Bonds and Insurances (4%)	$6,800	$21,800	$16,200
13	**Subtotal (**Items 9 through 13)	$215,900	$693,400	$513,100
14	Contingency (30%)	$64,800	$208,000	$153,900
15	**Total Construction Cost** (Sum of Items 13 and 14)	$280,700	$901,400	$667,000
16	Administration and Engineering (20%)	$56,100	$180,300	$133,400
17	**Total Estimated Project Cost**	$340,000	$1,080,000	$800,000

Table 5-3 provides the project costs, operations and maintenance (O&M) costs, and BCE results of the three alternatives for the relocated IEBL Discharge Station. The O&M costs assumed that number of labor hours to maintain the system will be 80 hours per year and were based on a percentage of the equipment and structures costs. The O&M cost for Alternative 2 was calculated based on the assumption that the pumps in the lift station will be operating 12 hours a day.

Table 5-3: IEBL Discharge Station Capital and O&M Costs and BCE Results

	Item	Alternative 1 West of CCWRF	Alternative 2 Northeast of RP-5	Alternative 3 North of SHF
1	Capital Cost	$340,000	$1,080,000	$800,000
2	Annual O&M Cost	$8,000	$30,800	$9,200
3	30-year NPV	$570,000	$1,950,000	$1,080,000

5.1.5 Implementation Schedule

The relocation of the discharge station could be implemented in a phased approach by relocating the existing two septage receiving stations one at a time. This sequencing will allow for the continued operation of the discharge station during transition from the exiting discharge station to the new discharge station, which will occur prior to the demolition of the existing IEBL Discharge Station.

5.1.6 Conclusions and Recommendations

The recommended location for the new discharge station is the north area of the RP-5 SHF (Alternative 3) as presented in this section.

In a subsequent meeting with the Agency to discuss the IEBL discharge station relocation, it was suggested to leave the IEBL discharge station at its current location. In the future, the Agency plans to consolidate the septage and high-strength industrial waste receiving station location and operation at RP-4, which is located in Rancho Cucamonga.

APPENDIX 5-A: OTHER ALTERNATIVES CONSIDERED FOR THE RELOCATION OF IEBL DISCHARGE STATION

Eight locations were considered for the new IEBL Discharge station. These options were as follows:

A. Chino Creek Wetlands and Education Park where trucks enter from El Prado Road and exit to Kimball Avenue
B. West of the Chino Creek Wetlands and Education Park where trucks enter and exit from and to El Prado Road
C. South of the Chlorine Contact Tanks at CCWRF where trucks enter and exit through a new opening to and from Telegraph Avenue
D. North of the Solar Panels at CCWRF where trucks enter and exit through the existing entrance off Telegraph Avenue
E. West of Existing Solar Panels at RP-5
F. West of the Headworks at CCWRF where trucks enter through the existing entrance off Telegraph Avenue and exit through a new opening onto Chino Hills Parkway
G. Northeast corner of RP-5 near the entrance off Kimball Avenue.
H. West of the RP-5 Solids Handling Facility where trucks will enter and exit through existing openings off Mountain Avenue.

Options A through E were considered infeasible and were eliminated from consideration due to major concerns and design constraints. These options are discussed in detail in this section.

Options A and B locate the new Discharge Station west of IEUA's LEED certified headquarters in the area with the Chino Creek Wetlands and Educational Park. Both options will require the discharge station to be fenced and to occupy approximately 140-ft by 56-ft space. Both options will occupy and disturb the wetland and require trenching through the park for construction of electrical conduits and water utility pipelines. The electrical conduits will need to extend to the RP-5 plant control station to send and receive signals in addition to providing power to the septage receiving stations, light fixtures, and security systems.

Option A will go through the middle of the Educational Park and cover an area of approximately 16,500 square feet (Figure 5.A-1). The hauling trucks will enter the discharge station through El Prado Road and exit onto Kimball Avenue. The exit is located approximately 25 feet away from a bus pad, which serves as a LEED credit to the headquarters. The roadways to and from the discharge station will be paved with asphalt concrete, requiring existing vegetation to be removed. A new 8-inch diameter sewer pipeline will also be constructed to connect the dump station manhole to an existing manhole on the IEBL on El Prado Road.

Option B will have the new discharge station parallel to El Prado Road and cover an area of approximately 18,750 square feet (Figure 5.A-2). The hauling trucks will enter and exit the Discharge Station through El Prado Road. Most of this area currently features trees and vegetation, which will need to be removed. A new 8-inch diameter sewer pipeline will also be constructed to connect the new dump station manhole to an existing manhole on the IEBL.

Relocating the discharge station at the Chino Creek Wetlands and Education Park is unfavorable due to the site's importance to the community and purpose in preserving and restoring the Prado Basin. This project was partially funded by a grant from the State Water Resources Control Board and serves as a learning facility to visiting student groups. Both options will require the existing vegetation to be uprooted. Approximately 1,000 volunteers participated with planting and irrigation activities throughout the Park, which was opened in April 2008; therefore, impacting the Park will be undesirable to the public. The pathways in Option A will also intercept existing public trails, which could pose safety concerns to the visitors of the Park.

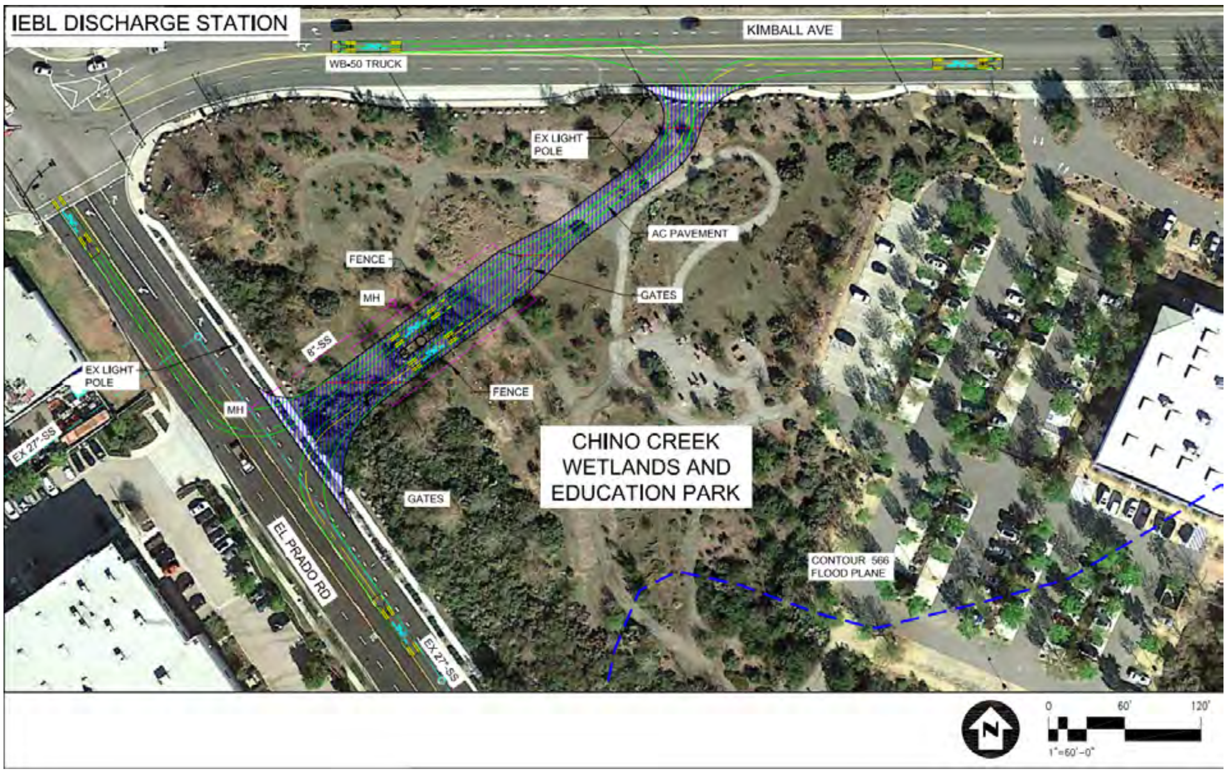


Figure 5.A-1: Option A overall layout

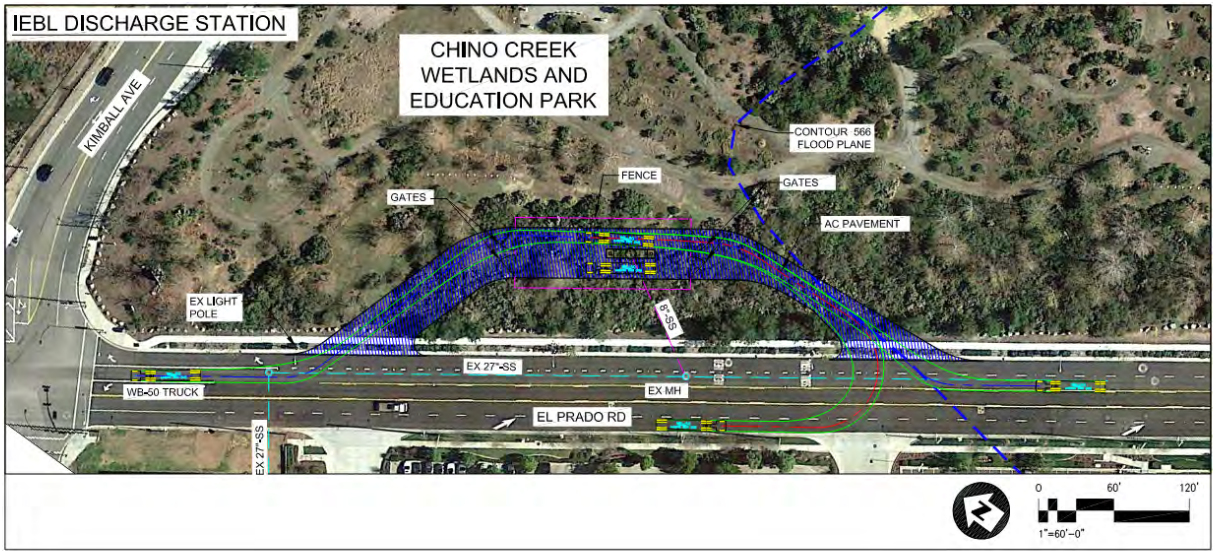


Figure 5.A-2: Option B overall layout

Option C has the new IEBL Discharge Station located south of CCWRF's existing chlorine contact tanks where the recycled water reservoir and pump station are located. Hauling trucks would enter and exit through a new opening off Telephone Avenue that would require part of the existing wall be demolished and fitted with a new entrance gate along with the demolition of some existing pipe and appurtenances (5.A-3). In addition, existing trees will be uprooted and removed, the curb will be modified, and the soiled ground will be paved with asphalt concrete to create this new entrance/exit.

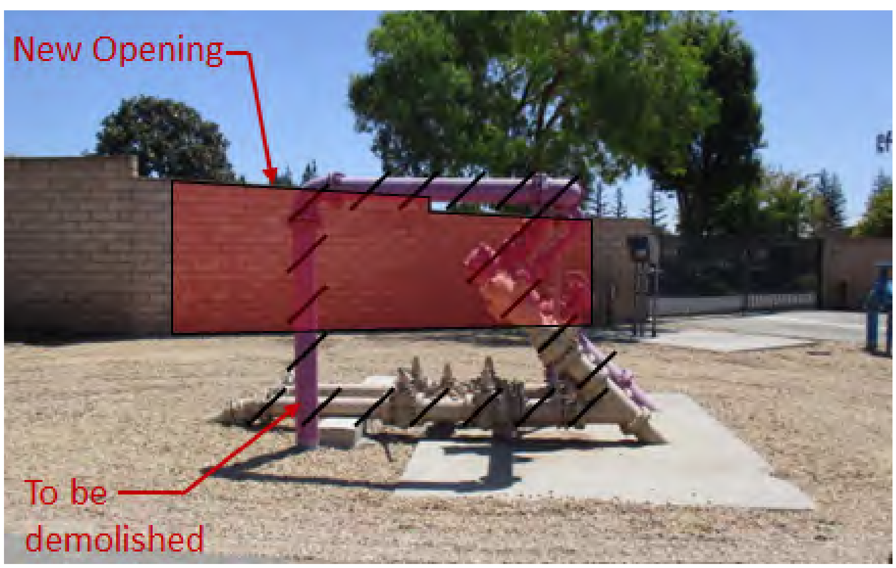


Figure 5.A-3: Potential opening for option C

The trucks would travel on the roof of the existing reservoir and between existing reservoir air vents to a new discharge station, which will be located at the south corner of CCWRF (Figure 5.A-4). A new 8-inch sewer pipeline will be constructed to connect the new dump station manhole directly to an existing manhole on the 27-inch IEBL. The hauling trucks will exit the premises by reversing into a space west of the chlorine contact tanks. This space provides the adequate turning radius required for WB-50 trucks to comfortably exit the CCWRF.

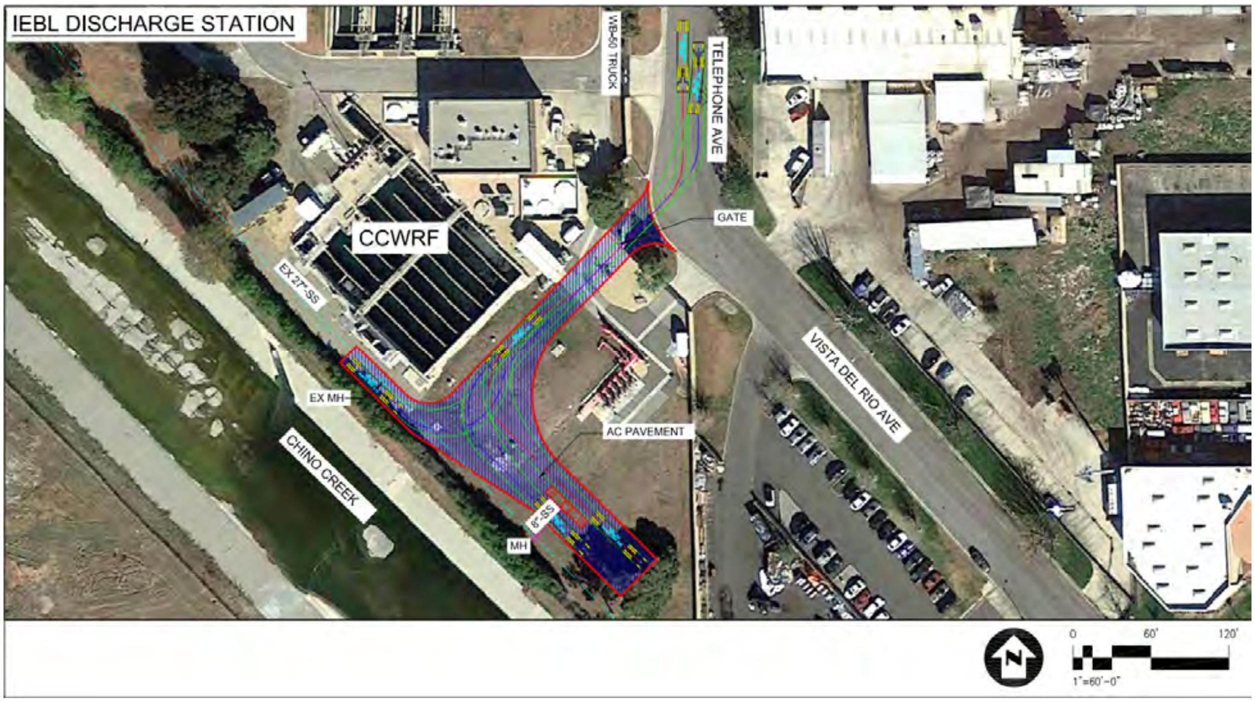


Figure 5.A-4: Option C overall layout

The major concern with this option is that the recycled water reservoir roof cannot structurally support truck traffic and the existing surrounding slopes are too steep for trucks to travel on. The design roof live load is only 400 psf, which is much less than the HS-20 live load required to support large semitrailers (WB-50 design vehicle). The roof will require major modifications to support these truck loads. In addition, the existing ground slope around the reservoir is too steep for hauling trucks to maneuver through as the slopes on the northeast and southwest sides are 5H:1V and 2H:1V, respectively. The two feet of soil that covers the reservoir's roof is part of the roof structural design, so maintaining the cover is desirable. Re-grading the surrounding area is infeasible due to the space constraints, especially on the northeast side. Locating the new Discharge Station at this location would also require demolishing and the creation of a new entrance opening.

Option D has the new IEBL Discharge Station located north of the solar panels at CCWRF. Trucks would enter and exit the premise through the existing entrance off Telegraph Avenue. Upon entering CCWRF, the trucks would follow the pathway delineated on Figure 5.A-5. Option D directs the trucks to a new discharge station located east of the existing headworks and north of the existing solar panels. Under this option, the new discharge station will encroach upon the existing curb by up to 15 feet horizontally. Therefore, the existing curb will need to be modified to accommodate the new discharge station and also to provide adequate turning radii. The existing site also contains solar panels, which would need to be relocated.

A new 8-inch diameter sewer pipeline would also be constructed to connect the new dump station manhole to a discharge manhole, which would connect to an existing manhole on the IEBL with another 8-inch diameter sewer pipeline. Under this configuration, no additional site security measures would be required because no new opening has been created and the discharge station is within the CCWRF. However, signals would still need to be transmitted to and from the plant operations center to monitor the dumping occurring at the new discharge station.

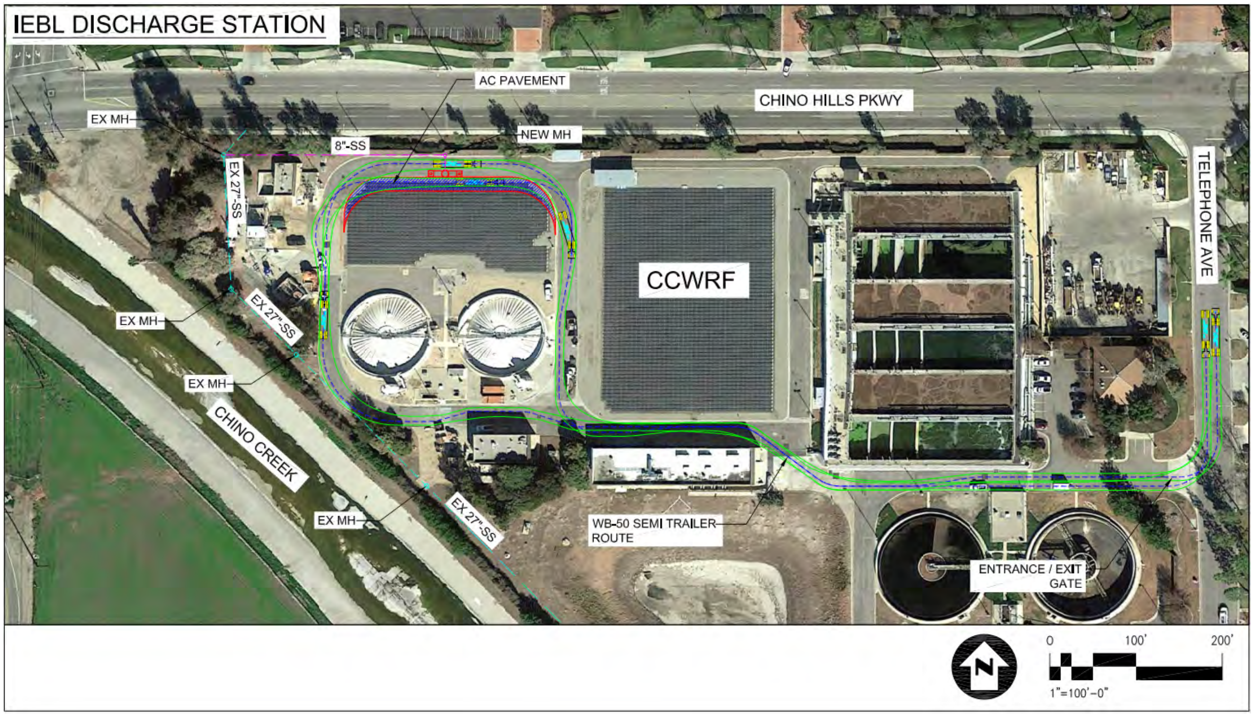


Figure 5.A-5: Option D overall layout

Option D is considered unfavorable, however, because trucks would need to enter CCWRF and would disturb current operations and raise security concerns. Based on conversations with IEUA, allowing outside private haulers access to the plant is undesirable. Relocating the solar panels will also pose challenges because modifying the existing design could jeopardize the original electrical output projections and will require reworking of the solar panel system.

An alternate location was also considered where the private haulers would enter and exit the Discharge Station from Chino Hills Parkway through new openings in the existing wall. To isolate the Discharge Station from CCWRF, new security fencing and gates would be constructed. To achieve the necessary turning radii, this configuration would encroach upon the existing solar panels' area even more. In addition, the new pathways would require modifications to the sidewalk and vegetation along Chino Hills Parkway. Therefore, this alternate configuration is also undesirable.

Option E locates the new Discharge Station west of the existing solar panels at RP-5. Trucks would enter and exit the RP-5 through the existing entrance off Kimball Avenue. Upon entering RP-5, the trucks would follow the pathway shown on Figure 5.A-6. Under this option, the existing solar panels would be relocated and the new pathway would be paved with asphalt concrete. A new 8-inch diameter sewer pipeline would be constructed to connect the new dump station manhole to a new manhole, which would connect to an existing manhole on the IEBL with another 8-inch diameter sewer pipeline. Under this configuration, no additional site security measures would be required because the discharge station would be within the RP-5. However, signals would need to be transmitted to and from the plant control station to monitor the dumping occurring at the new discharge station.

Figure 5.A-6: Option E overall layout

Option E is also considered undesirable because private haulers would have access to RP-5. In addition, the haulers would be sharing a pathway with maintenance trucks servicing RP-5, which would increase in number due to the future construction of solids handling facilities at RP-5. And like Option C, relocating the solar panels could jeopardize the original electrical output projections and would require reworking of the solar panel system.

Inland Empire Utilities Agency
A MUNICIPAL WATER DISTRICT

Evaluation of Onsite Centrate Treatment and Offsite Recycle Flow Discharge

Predesign Report
Volume III, Chapter 6

February 28, 2017

submitted by

PARSONS

in association with

Brown AND Caldwell

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

THIS PAGE INTENTIONALLY LEFT BLANK.

CHAPTER 6: EVALUATION OF RP-1 AND RP-5 ONSITE CENTRATE TREATMENT

6.1 INTRODUCTION

This introductory section presents a project background, understanding and approach, and a list of alternatives considered.

6.1.1 Understanding and Approach

Centrate from Regional Water Recycling Plant 1 (RP-1) currently is discharged to the Non-Reclaimable Wastewater System (NRWS) line, but the Inland Empire Utilities Agency (IEUA) is considering alternatives because of the surcharges associated with using this brine line. The planned plant expansion at RP-1 may provide a convenient opportunity to install flexibility to treat centrate at the plant. Alternatively, the planned expansion at Regional Water Recycling Plant 5 (RP-5) may allow the opportunity to send centrate from RP-1 to RP-5, where RP-5 can be expanded to treat the additional load from RP-1 centrate. This business case evaluation (BCE) will evaluate alternatives for managing centrate treatment at RP-1.

Currently Regional Water Recycling Plant 2 (RP-2) sends recycle flows to RP-5. In relocating the solids treatment facility at RP-5, new options for managing these recycle flows may be needed. Flexibility should be provided to allow RP-5 to either treat the recycle flows or discharge these flows to the IEBL. This BCE will determine the most cost-effective approach to managing centrate treatment at RP-5. All BCE analysis are provided in Exhibit I of this Volume.

6.1.2 List of Alternatives

The following four alternatives are considered in the BCE for centrate handling at RP-1:

- Continue use of the NRW pipeline
- Recycle centrate back to RP-1 liquid treatment
- Provide separate treatment of centrate at RP-1
- Transfer centrate from RP-1 to RP-5 for combined treatment
- A combination of the above alternatives

The following three alternatives are considered in the BCE for centrate handling at RP-5:

- Recycle centrate to the RP-5 liquids treatment system
- Provide separate centrate treatment at RP-5
- Discharge centrate to the IEBL
- A combination of the above alternatives

6.2 CENTRATE FLOW AND CHARACTERISTICS

This section describes available data, methodologies, and assumptions used to develop centrate flow projections and centrate characteristics. This BCE was conducted during early stages of the project, and limited mass balance information was available. For this BCE, the estimation of centrate flows and characteristics uses the best information available at the time to provide an assessment of the alternatives. It is assumed that this approach will be sufficient for recommending centrate handling approaches, and selection of these technologies will allow continued development and refinement of future project mass balance efforts.

6.2.1 Review of Available Data

The following available data were used to project sludge and centrate production and characteristics at the IEUA facilities. Available data and their use for this evaluation are summarized in Table 6-1.

Table 6-1: Summary of Available Data

Data Description	Note
Daily influent flows and centrate flows at RP-1 and daily influent flows at RP-5 from 2/11/2016 to 3/9/2016	Historical centrate production rates were established for RP-1 based on ratio of centrate flow to influent flow (gallons of centrate/MG of plant influent). Because sludge from RP-4 is sent to and treated at RP-1, the ratio needs to account for RP-4 influent flows. However, RP-4 influent flow data are not provided for this period. Therefore, a flow of 10.5 mgd was assumed based on flow data given in other periods. Sludge from RP-5 and CCWRF are currently treated at RP-2. Centrate flow data at RP-2 are not available. Therefore, the same ratio was assumed for both RP-1 and RP-5.
Historical influent characteristics at RP-1, RP-5, and CCWRF from 2010 to 2015	Historical plant influent characteristics were reviewed but the plant influent concentrations used for this analysis are based on design concentrations for each facility.
RP-1 centrate characteristics data in February and March 2016	Centrate characteristics data were reviewed, but the centrate concentrations used for this analysis are based on design concentrations and are assumed to be the same at both facilities.
Solids production rates (lb of solids/MG of plant influent) at RP-5 and CCWRF	Solids production at IEUA facilities were estimated through efforts associated with Chapters 4 and 7 through preliminary mass balance modeling. Refer to these documents for details. [a]

[a] Chapter 4: Evaluation of Ultimate Expansion of RP-5, and Chapter 7: BCE of RP-5 Secondary Treatment Alternatives

Table 6-1 summarizes the flow data and calculated flow ratios used to estimate centrate production rates. Historical centrate production rates from RP-1 were evaluated to develop centrate production rate to influent flow rate ratios at RP-1 from February 11 to March 9, 2016. Plant influent flow rates presented in Table 6-2 include the influent flows from both RP-1 and Regional Water Recycling Plant 4 (RP-4), because sludge from RP-4 is treated at RP-1. Based on these data, a centrate production rate ratio of 9,220 (gallons of centrate per million gallon of plant influent) was used.

Table 6-2: Calculation of Centrate Production Rate Ratio

Date	Plant Influent Flow[a], mgd	Centrate Flow, gpd	Centrate Production Rate, Gallons/MG Influent
2/11/2016	34.7	368,483	10,619
2/12/2016	34.2	343,056	10,041
2/13/2016	34.6	395,555	11,433
2/14/2016	34.9	342,052	9,815
2/15/2016	34.2	333,151	9,727
2/16/2016	36.1	320,878	8,876
2/17/2016	34.8	329,769	9,479
2/18/2016	35.7	378,577	10,613
2/19/2016	35.7	386,073	10,805
2/20/2016	35.0	334,107	9,549
2/21/2016	35.9	346,548	9,661
2/22/2016	36.5	321,836	8,814
2/23/2016	35.6	328,726	9,242
2/24/2016	35.0	310,876	8,877
2/25/2016	34.6	319,280	9,223
2/26/2016	34.1	351,776	10,313
2/27/2016	33.4	337,988	10,109
2/28/2016	34.9	264,682	7,580
2/29/2016	35.1	330,905	9,423
3/1/2016	34.2	308,920	9,033
3/2/2016	34.6	304,978	8,811
3/3/2016	36.2	267,461	7,383
3/4/2016	34.3	378,901	11,057
3/5/2016	35.2	285,713	8,127
3/6/2016	34.3	307,109	8,957
3/7/2016	37.0	295,193	7,984
3/8/2016	36.7	210,594	5,736
3/9/2016	36.7	252,020	6,869
Average	35.1	323,400	9,220

[a] RP-1 and RP-4 combined influent flow. Historical RP-4 influent flow data are not available for the period of evaluation. 10.5 mgd influent flow was assumed for RP-4.

The design plant influent characteristics at RP-1 and RP-5 are summarized in Table 6-3. The influent characteristics were selected during a RP-1 and RP-5 Expansion PDR Flow and Loading Analysis meeting on March 7, 2016, which included a thorough review of historical data and previous master planning efforts. The design values were selected based on max month averages (90th percentile). The design plant influent concentrations for RP-5 include the centrate contributions (currently returned from RP-2). Since the centrate contribution is included, the actual projected influent loadings to RP-5 may be lower when RP-2 is decommissioned and sludge is treated at RP-5 (as centrate loadings are then internal to the plant).

Table 6-3: Influent Characteristics, mg/L

Facility	BOD	TSS	NH_3-N	TKN	VSS/TSS
RP-1	600	550	40	65	0.85
RP-5	500	400	50	65	0.85

Table 6-4 summarizes the solids production rate ratios used to calculate projected solids production rates. The ratios for RP-1 are approximately 25% higher than those for RP-5 due to the higher BOD and TSS influent concentrations.

Table 6-4: Solids Production Rate

Facility	Average Annual, lb/MG Influent		Maximum Month, lb/MG Influent	
	Primary Sludge	WAS	Primary Sludge	WAS
RP-5	1,700	800	2,500	1,500
CCWRF	2,125	1,000	3,125	1,875

6.2.2 Centrate Flow Projections

Future centrate flows were initially estimated using two different methods: from the calculated centrate flow to influent flow ratio and from estimated sludge production rates. In both cases, plant influent flows were applied to the calculated ratios. Table 6-5 summarizes the flow projections at each plant through 2050. For this analysis, flows between the given years were interpolated.

Table 6-5: Projected Influent Flows at IEUA Facilities, mgd

Facility	2013	2020	2030	2035	2040	2050
RP-1	24.7	26.2	30.3	32.2	33.7	32.9
RP-4	11.1	12.7	13.0	13.0	13.0	17.8
RP-5	4.3	8.9	14.7	17.1	19.7	23.6
CCWRF	7.4	7.6	7.8	7.9	8.1	8.3
Montclair Diversion	3.4	3.6	3.8	3.8	3.9	3.9
Whispering Lakes PS	1.5	1.5	1.6	1.6	1.7	1.7
Haven PS	0.1	0.1	0.2	0.2	0.3	0.3

6.2.2.1 Centrate Flow Projections Based on Centrate Production Rate Ratio

The following assumptions were used to project centrate production rates at RP-1 and RP-5 using the centrate production rate ratio:

- Ratios of centrate flow to plant influent flow (see Table 6-2) calculated based on data from February to March 2016 are representative of those of RP-1 and RP-5.
- The ratio of centrate flow to plant influent flow will remain the same for future flow and load conditions and solids stream treatment technologies to be used.
- Because sludge from RP-4 is sent to and treated at RP-1, the ratio needs to account for RP-4 influent flows. However, RP-4 influent flow data are not provided for this period. Therefore, a flow of 10.5 mgd was assumed based on flow data given in other periods.
- A peaking factor of 1.0 was selected for sizing centrate treatment process as flow and load attenuation is expected across the liquid-stream and solids stream processes. Additional considerations on peaking factors should be considered for the recommended centrate handling alternatives, as applicable.
- For centrate generation at RP-1, the influent flows for both RP-1 and RP-4 are used as the sludge from RP-4 is sent to RP-1.
- For centrate generation at RP-5, the influent flows for both RP-5 and Carbon Canyon Water Recycling Facility (CCWRF) are used as the sludge from CCWRF will be sent to RP-5.
- While certain flows in the service area (Montclair Diversion, Whispering Lakes Pump Station [PS], and Haven PS can be routed to either RP-1 or RP-5, and Montclair flow can also be routed to CCWRF, the centrate flows at each facility were calculated assuming that these flows are included to provide the most conservative estimate. For the centrate flow at RP-5, the Montclair Diversion flow is counted only once.
- For the design centrate flow at RP-5 (for sizing the sidestream treatment processes), a design capacity of 40 million gallons per day (mgd) was assumed for RP-5, which accounts for flows from CCWRF when it is decommissioned.

Based on the assumptions and data described above, centrate projections in 2045 based on the centrate production rate ratio were calculated and are summarized in Table 6-6

Table 6-6: Projected Centrate Flows in 2045
Based on Centrate Production Rate Ratio, gpd

RP-1 + PR-4[a]	RP-5 + CCWRF[b]
503,400	368,800

[a] For RP-1 and RP-4, the projected 2045 flows were used to calculate the design centrate flow.
[b] For RP-5 + CCWRF, the 2035 design capacity for RP-5 with CCWRF decommissioned was used to calculate the design centrate flow.

6.2.2.2 Centrate Flow Projections Based on Sludge Production Rate

Centrate flows were also estimated by calculating the digested sludge production rates and through mass balance calculations across the dewatering process. The following assumptions were used to project centrate productions based on sludge production rate:

- Sludge production rate at RP-1 is about 25% higher than that of RP-5.
- Sludge production rates will remain the same for future flow and load conditions and solids stream treatment technologies to be used.
- Total solids contents of thickened sludge and dewatered cake are 4.5 percent and 25 percent, respectively.
- As a conservative estimate, solids capture rates of sludge thickening and dewatering processes are 100 percent.

Based on the assumptions and data presented above, centrate projections in 2045 based on sludge production rate were calculated and are summarized in Table 6-7.

Table 6-7: Projected Centrate Flows in 2045 Based on Sludge Production Rate, gpd

RP-1 + PR-4[a]	RP-5 + CCWRF[b]
322,200	256,000

[a] For RP-1 and RP-4, the projected 2045 flows were used to calculate the design centrate flow.
[b] For RP-5 + CCWRF, the 2035 design capacity for RP-5 with CCWRF decommissioned was used to calculate the design centrate flow.

6.2.2.3 Centrate Flow Projections Used for Centrate Treatment Evaluation

As shown in Tables 6-6- and 6-7, centrate projections calculated from the two methods are different. Those calculated from centrate production rate are significantly higher than those from sludge production.

Such discrepancy is likely due to limited available data for this evaluation. For example, centrate production rate data during a period of only approximately one month at RP-1 were used to predict centrate production rates at both RP-1 and RP-5 in the future. The results can be flawed if the influent and/or centrate flows during that limited period were not representative of typical operation. Assumptions were also made regarding the influent flows at RP-4 and the applicability of the calculated ratio at both facilities. Any deviations from these assumptions would further exacerbate the discrepancies.

The apparent discrepancy between centrate flow projections derived from two methods is not uncommon for high-level evaluations at the early stage of a project. The Parsons/Brown and Caldwell (BC) team will continue to refine centrate projections as more process data become available.

For the purpose of this analysis, the higher, more conservative centrate projections based on the centrate production ratio (Table 6-6) were used for the BCE. The BCE was conducted based on the period from 2016 to 2045.

6.2.3 Estimated Centrate Characteristics

Table 6-8 summarizes the centrate characteristics used for the centrate treatment BCE.

Table 6-8: Centrate Characteristics, mg/L

COD	TSS	NH_3-N	P
850	250	1,000	120

6.3 DEVELOPMENT OF ALTERNATIVES

This section describes the development of centrate treatment technology alternatives.

6.3.1 Pre-Screening of Representative Centrate Treatment Technologies

This section describes pre-screening of centrate treatment technologies.

6.3.1.1 Sidestream Nitrogen Removal Technologies

This section provides an overview of sidestream treatment technologies that could reduce centrate impact on secondary treatment processes and improve nitrogen removal. The strategies discussed in this section include the following:

- Centrate equalization
- Biological Augmentation Reactor (BAR)
- Separate Sludge Nitrification
- Nitritation
- Anammox
- Ammonia Stripping

Centrate Equalization

Centrate equalization can be implemented by plants that have intermittent thickening and dewatering operations to provide a more continuous loading of ammonia back to the main liquid stream treatment process. An equalization basin allows the plant to provide a constant centrate flow rate. For plants that thicken and dewater continuously, equalization allows the plant to return more centrate during low influent loading periods when the secondary process has available treatment capacity. Equalization does not reduce the ammonia loading treated in the secondary process, but it does provide the plant with the ability to control when the ammonia loading is returned to match the secondary process capacity.

Sizing of equalization depends on planned dewatering operation schedules, typically ranging from 24 hours of equalization for plants that dewater continuously up to 72 hours or more for plants that do not dewater on weekends or holidays.

Centrate and RAS Reaeration Basin

The BAR process combines RAS from the secondary system with centrate in an aerated reactor before entering the liquid treatment process. The BAR process offers the advantage of bioaugmentation of the nitrifier population and increases the rate of nitrification in the downstream bioreactor. This allows operation at a comparatively lower aerobic solids retention time (SRT) for full nitrification and a lower mixed liquor suspended solids (MLSS) for reduced solids load to the clarifiers. For best performance, the centrate return flow should be equalized and introduced at a constant rate to maintain a steady source of substrate (ammonia) rather than feast/starve cycles. Advantages and disadvantages of BAR are shown in Table 6-9.

Table 6-9: BAR Advantages and Disadvantages

Advantages	Disadvantages
• Operational flexibility • Less tankage for nitrification • Can split and bypass a portion of RAS and/or centrate for operational flexibility • Reduced mixed liquor recycle requirement • Provides bioaugmentation of nitrifying organisms	• Nitrogen not fully removed; only converted to nitrate, which must be removed in the liquid treatment process • May require supplemental alkalinity • No reduction in total air demand • No reduction in supplemental carbon requirements

Separate Sludge Nitrification

One potential sidestream treatment technology would be to nitrify the sidestream flow using a separate activated sludge system. One means often employed is a nitrifying sequencing batch reactor (NSBR), which is a fill-and-draw activated sludge system. In this system, wastewater is added to a single “batch” reactor, treated to remove pollutants, and then discharged. Equalization, aeration, and clarification can all be achieved using a single batch reactor.

To optimize the performance of the system, two or more batch reactors are used in a predetermined sequence of operations. Sequencing batch reactor (SBR) systems have been broadly used to treat both municipal and industrial wastewater. They are uniquely suited for wastewater treatment applications characterized by low or intermittent flow conditions such as for sidestreams. The NSBR would be installed to treat centrate prior to sending the flow back to the headworks. The flow leaving the NSBR would still need to denitrify in the main stream flow. Some denitrification would probably occur in the headworks and primary clarifiers, with the rest in the secondary process. Advantages and disadvantages of an NSBR are shown in Table 6-10.

Table 6-10: NSBR Advantages and Disadvantages

Advantages	Disadvantages
• Established technology • Simple reactor vessel • Operational flexibility and control • Potential capital savings by incorporating separation/other equipment within a common basin • Reduce final effluent ammonia discharge concentration	• Alkalinity addition required • Oxygen transfer limitations result in large reactor volume • Heavy reliance on automated systems to control process • Potential of washing out non-settled biomass during the decant phase • Nitrogen not fully removed; only converted to nitrate, which must be removed in the liquid treatment process and may result in supplemental carbon requirements

SHARON®

The Single Reactor High-Activity Ammonia Removal Over Nitrite (SHARON) process is a high-rate nitritation/denitrification two-step process. In the first step, all of the ammonia is oxidized to nitrite (nitritation) and in the second step, the nitrite is reduced by denitrifiers. The second step requires an external carbon source to fuel the biological process.

Advantages and disadvantages for the nitritation reactor are summarized in Table 6-11.

Table 6-11: Nitritation Advantages and Disadvantages

Advantages	Disadvantages
• Lower oxygen demand than conventional nitrification • No clarifier is required with two tanks in series • Removes nitrogen from the sidestream	• Higher oxygen demand than ANAMMOX • Challenging process control • New technology for operators • Requires external carbon source addition • Separate process that must be operated • Risk of incomplete ammonia reduction • A significant amount of nitrite is converted to nitrate • Requires cooling water to maintain temperature

Anammox

Three treatment technologies are considered for sidestream nitrogen removal via anammox bacteria: World Water Works' DEamMONification (DEMON®) process, Veolia's ___ (ANITA™ Mox) process, and Paques' ANaerobic AMMonia OXidation (ANAMMOX®) process.

DEMON Process

As opposed to traditional total nitrogen removal through nitrification and denitrification, the DEMON process uses a de-ammonification process in a suspended-growth SBR configuration for nitrogen removal. The de-ammonification process uses a special type of bacteria to convert ammonia to nitrogen gas without the need of an external carbon source and with about half of the energy compared to that typically required in a traditional total nitrogen removal process. The special bacteria used in de-ammonification are called anammox. The DEMON process involves partially nitrifying ammonia with ammonia-oxidizing bacteria (AOB), followed by anaerobic reaction involving nitrite removal by conversion to nitrogen gas carried out by anammox bacteria. Figure 6-1 shows the traditional nitrification and denitrification process in comparison to anammox processes.

In the SBR configuration, the reactor is gradually filled with the centrate and then alternatively aerated and mixed. After the aeration phase, aeration and mixing are both stopped and the sludge blanket is allowed to settle. Because the anammox bacteria are very slow growth, the DEMON process uses cyclones to separate the anammox granules from the mixed liquor.

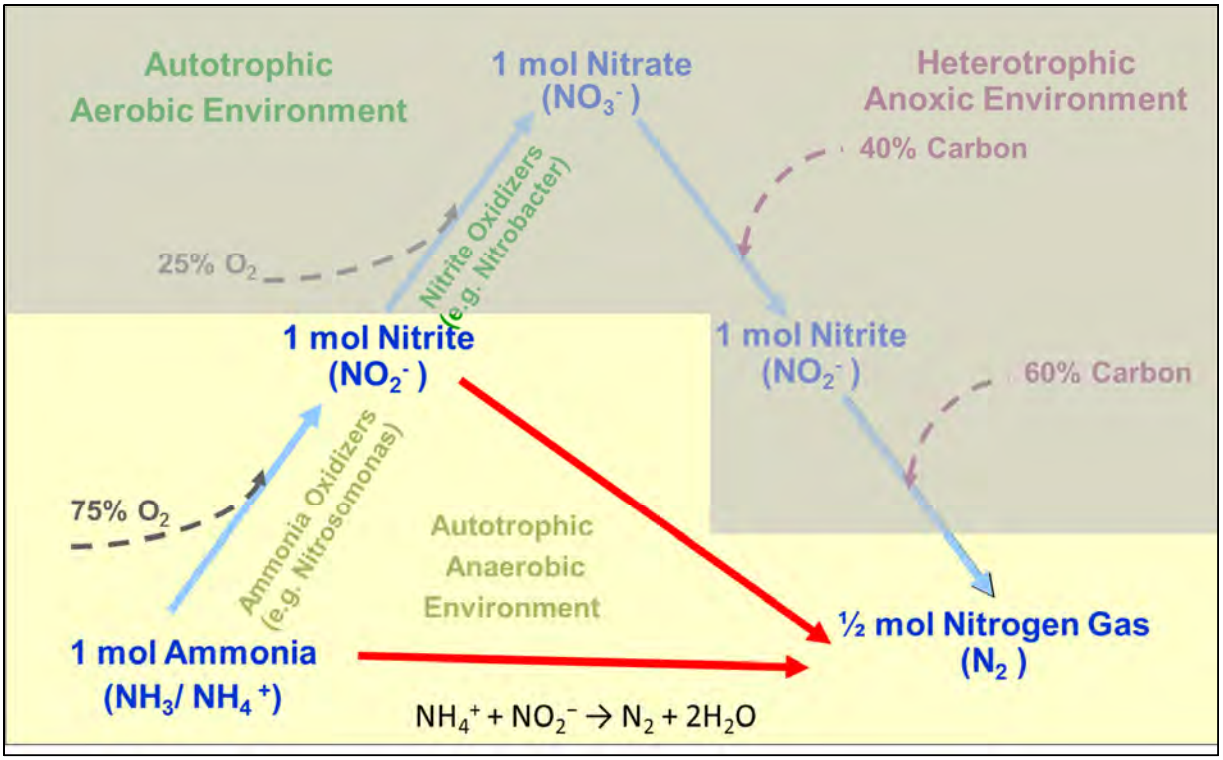


Figure 6-1: Traditional Nitrogen Removal Process in Comparison to Any Anammox Nitrogen Removal Process

ANITA Mox Process

The ANITA Mox process is similar to the DEMON process, also using a de-ammonification process for nitrogen removal. However, ANITA Mox uses media in a moving-bed biofilm reactor (MBBR) to treat the ammonia-rich influent. In the MBBR, carriers are kept in suspension by aeration and mixing. A biofilm grows on the plastic media, with the AOB on the outer layers of the biofilm and the anammox bacteria on the inner layers of the biofilm. Thus, nitritation occurs on the outer layer, while anammox carries out nitrite oxidation in the inner layer as shown in Figure 6-2. A benefit of the use of media is that it prevents the washout of the anammox bacteria from the reactor. Other advantages to the ANITA Mox process are similar to those of DEMON.

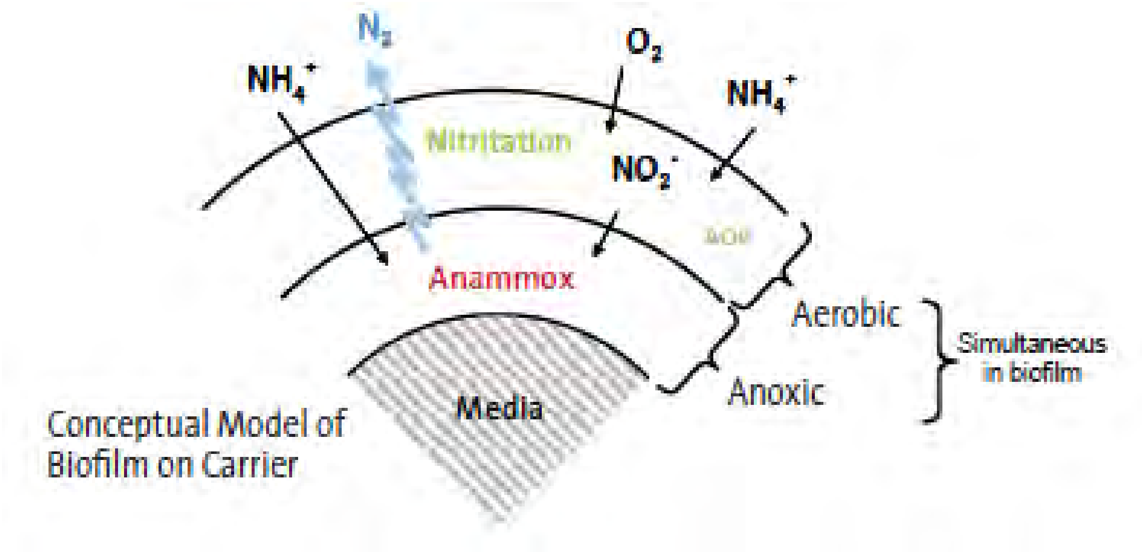


Figure 6-2: ANITA™ Mox Biofilm Growth on Media

Source: http://technomaps.veoliawatertechnologies.com/anita/en/anita_mox.htm?bu=doc

ANAMMOX Process

The ANAMMOX process also uses anammox bacteria in combination with nitrification to convert ammonium directly into nitrogen gas. The ANAMMOX process uses an upflow reactor. The reactor is aerated, contains granular biomass, and is continuously fed wastewater. The reactor is aerated to provide mixing and contact with the biomass. The effluent leaves the reactor by passing through the anammox separator. The granular biomass is separated from the effluent, thus retaining the biomass in the reactor and eventually ensuring high biomass content. With such high biomass content, conversion of ammonia into nitrogen gas is efficient in a small reactor volume. Figure 6-3 shows a typical Paques ANAMMOX reactor.

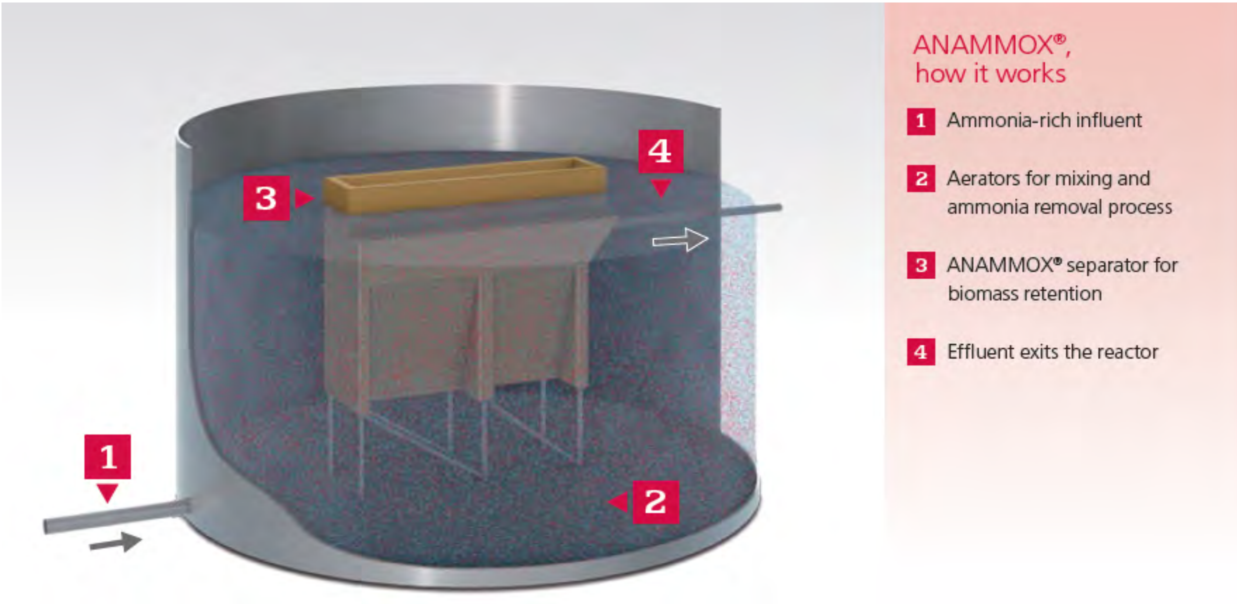


Figure 6-3: Paques Anammox Reactor

Source: Paques Vendor Pamphlet

Advantages and Disadvantages of the Various Anammox Processes

In summary, the advantages and disadvantages with the anammox method for sidestream treatment are presented in Table 6-12.

Table 6-12: Annamox Advantages and Disadvantages

Advantages	Disadvantages
• Lower aeration energy requirement (less than half) because only about half of the ammonium supplied has to be oxidized in the reactor • Typically no supplemental alkalinity requirement • Does not require an external organic carbon source (such as methanol) because ammonium is used the electron donor in the reactor • Lower sludge output because of the low yield of the anammox bacteria • Retains a smaller total footprint in comparison to what would be required in a secondary treatment expansion, assuming the sidestreams were routed to the headworks	• New technology for operators • Separate process that must be operated

Ammonia Stripping

Another potential alternative for sidestream nitrogen removal is ammonia stripping. In this physical/chemical process, ammonia is removed by changing the operating conditions such as temperature and/or pH to shift the liquid-gas equilibrium favoring transfer of ammonia from the liquid to gas phase. Ammonia stripping is typically done in a packed bed column to enhance mass transfer, but that limits its applications to a low-solids stream with lower potential for fouling of the column media. Ammonia stripping is more commonly used in industrial applications and may be used in conjunction with an adsorption process to recover the ammonia as ammonium sulfate.

Anaergia Side Stream Ammonia Recovery (SBSA) Process

One example of an ammonia stripping system is the Anaergia Side Stream Ammonia Recovery (SBSA) process designed for wastewater applications. The SBSA process is a proprietary commercial process for sidestream treatment. It involves ammonia stripping from digestate centrate using waste heat and submerged aeration. After dewatering of the digested sludge, the centrate is pre-heated using heat recovered from the ammonia stripped effluent and waste heat from a combined heat and power (CHP) system. The heated filtrate then enters the first of a series of aerated tanks where carbon dioxide is stripped to increase pH. Up to 90 percent ammonia removal can be achieved at conditions where the pH is increased to above 9 and temperature is increased to above 60 deg C. The ammonia rich gas from the strippers can then be sent to an acid gas scrubber, where sulfuric acid is added to lower the pH and ammonium sulfate is generated.

The Anaergia system was designed to allow application in a municipal wastewater treatment plant by including a stripping process that does not use packed bed columns, which eliminates the need for any pre-treatment filtration process to prevent fouling of the column media. Temperature adjustment is achieved by using waste heat from a CHP process. If a CHP process is not included in the treatment facility, then the centrate stream will then need to be heated separately, which could result in significant energy requirements. Chemical addition for pH adjustment in the stripping process is not needed; however, if acid scrubbing is used in conjunction with the stripping process, addition of sulfuric acid is required. The recovered ammonium sulfate may be sold as a fertilizer product if a market can be found.

Further evaluation of this process is needed to determine its feasibility and cost-effectiveness. It is not included in the BCE analysis described below.

6.3.1.2 Struvite Removal Technologies: WASSTRIP + Ostara, AirPrex

This section describes struvite removal technologies, including Waste Activated Sludge Stripping to Remove Internal Phosphorus (WASSTRIP) combined with Ostara and AirPrex.

Ostara and WASSTRIP

Ostara markets the Pearl reactor, which produces a struvite precipitate on the dewatering filtrate or centrate stream. To maximize phosphorus release and recovery while minimizing struvite precipitation upstream of the Pearl reactor, the Pearl process will be combined with Clean Water Institute's patented process called WASSTRIP. The combined process minimizes the sidestream phosphorus load and struvite formation within the biosolids system, while also reducing sidestream ammonium loads and solids quantities for disposal. Ostara also claims that the combined processes can reclaim lost dewatering performance (which is often observed in biological phosphorus [Bio-P] facilities), increasing the dewatered biosolids concentrations and reducing polymer demand for dewatering. The resulting struvite product is purchased by Ostara and sold to the public or to other fertilizer manufacturers as Crystal Green®. The Ostara/WASSTRIP process has eight current installations with another five currently under construction or design. Most projects are in the United States and Canada.

The WASSTRIP process is designed to cause a release of intracellular phosphate reserves from the waste-activated sludge (WAS). Bacteria uptake phosphorus when exposed to cyclical anaerobic and aerobic conditions, such as conditions existing in plants that perform Bio-P removal or anaerobic selectors to control filamentous bacterial growth. While the facilities at IEUA do not use either Bio-P or anaerobic selectors, the high phosphate concentrations in the digested sludge suggest that the bacteria are storing some intracellular phosphate. To validate the utility of the WASSTRIP process, pilot-scale testing is necessary.

The WASSTRIP process holds WAS for approximately 12 hours (6 to 20 hours) in an anaerobic environment while providing a form of readily biodegradable chemical oxygen demand (COD). These conditions mimic the anaerobic environment in the anaerobic selector that prompts the phosphorus-accumulating organisms (PAOs) to release internal reserves of polyphosphate. Effluent from the WASSTRIP tank is thickened to 2 to 3 percent solids using the plant's thickening process. The thickener subnatant, rich in phosphate, is then combined with centrate from the centrifuges and passed to the Pearl reactor. The thickened WAS is sent to digestion for solids stabilization.

The Pearl reactor creates an environment that promotes struvite formation in a controlled location. It does this by treating thickening and dewatering streams in a high-pH environment with added magnesium to increase the struvite precipitation potential in a location that will not cause operations and maintenance (O&M) issues. To do this, Ostara increases the pH of the treated streams (filtrate, centrate, etc.) in the Pearl reactor to approximately 9 using caustic soda (i.e., sodium hydroxide [NaOH]). Additional magnesium is also added, most commonly as magnesium chloride ($MgCl_2$), because magnesium is typically the limiting component (lowest concentration) for precipitating struvite. A process flow diagram for the Ostara Pearl system with WASSTRIP is presented in Figure 6-4.

The Pearl reactor operates as a fluidized bed reactor, growing the struvite crystals until they reach 0.9 to 3.0 millimeters (mm) in diameter. The large struvite crystals or "prills" (see Figure 6-5) are then harvested for use as fertilizer or to supplement a fertilizer product. Ostara claims to remove up to 88 percent of the sidestream phosphorus load.

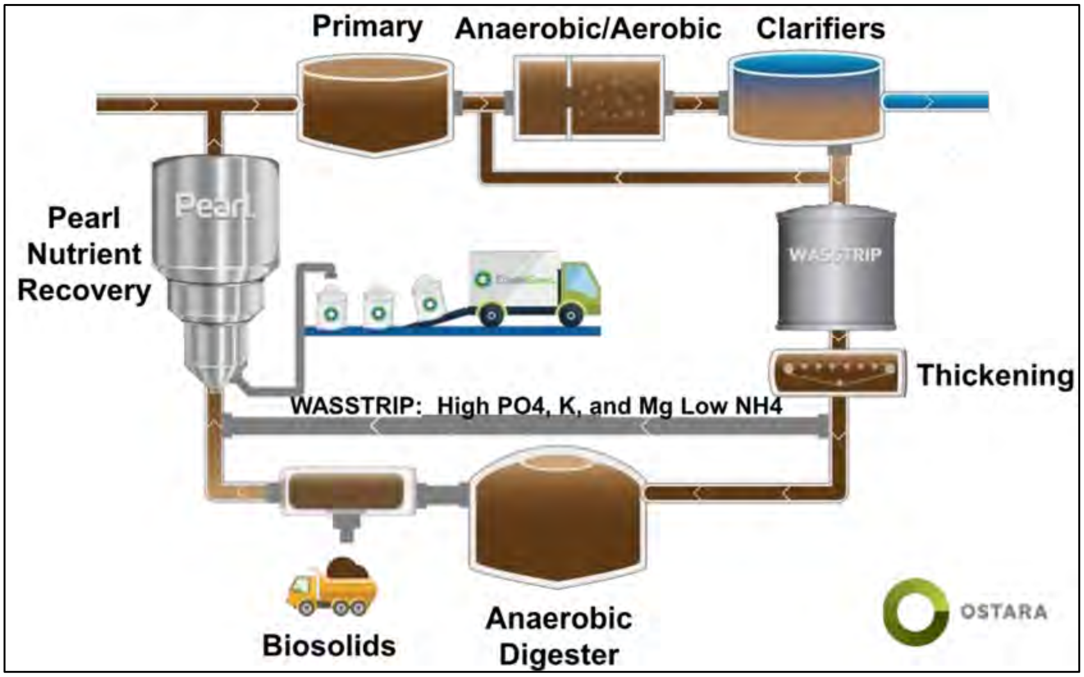


Figure 6-4: Ostara Sidestream Phosphorus-Removal Process Diagram

Source: Ostara

Figure 6-5: Struvite Produced in a Pearl Reactor

0.9, 1.5, 3.0, and 4.5 mm prill size (Source: Ostara)

AirPrex

CNP markets the AirPrex reactor, which, like Ostara's Pearl system, precipitates struvite. However, where Ostara precipitates struvite on "clean" sidestreams of thickener and dewatering filtrate and centrate, the AirPrex system is designed to remove struvite from the digested sludge stream prior to dewatering. The AirPrex system has two modes of operation: struvite "harvesting" and struvite "sequestration," which leaves the struvite in the sludge rather than separating it for sale. The AirPrex system will minimize sidestream phosphorus load and struvite formation within the dewatering system while also reducing sidestream ammonium loads and solids quantities for disposal. CNP also claims that the AirPrex system can reclaim lost dewatering performance, increasing the dewatered biosolids concentrations and reducing polymer demand for dewatering. The CNP AirPrex system has 6 European installations and 1 Chinese installation, and 28 projects in planning or design in the United States.

6.3.2 Principles of Operation

The AirPrex reactor treats anaerobically digested sludge with high phosphate and ammonium concentrations due to the breakdown of organic content. The digested sludge is transferred to the AirPrex reactor, where it is aerated using coarse-bubble diffusers to strip carbon dioxide (CO_2) and increase the pH. This is done in lieu of the chemical pH adjustment used by other systems. A supplemental source of magnesium (typically $MgCl_2$) is injected to increase the magnesium concentration and initiate struvite precipitation. CNP claims that the AirPrex reactor is capable of removing 90 to 95 percent of the sidestream phosphorus load. If the reactor is operated in the struvite sequestration mode (i.e., no interest in producing a fertilizer product), then the digested sludge stream with precipitated struvite is sent to dewatering. When left in the digested sludge, the struvite can enhance the nutrient value of the biosolids. If harvesting of struvite is desired, struvite-rich digested solids are removed from the bottom of the AirPrex reactor and a Huber Coanda grit washer is used to rinse the majority of organics from the struvite. See Figure 6-6 for a process flow diagram of the AirPrex system. Figure 6-7 shows the struvite product.

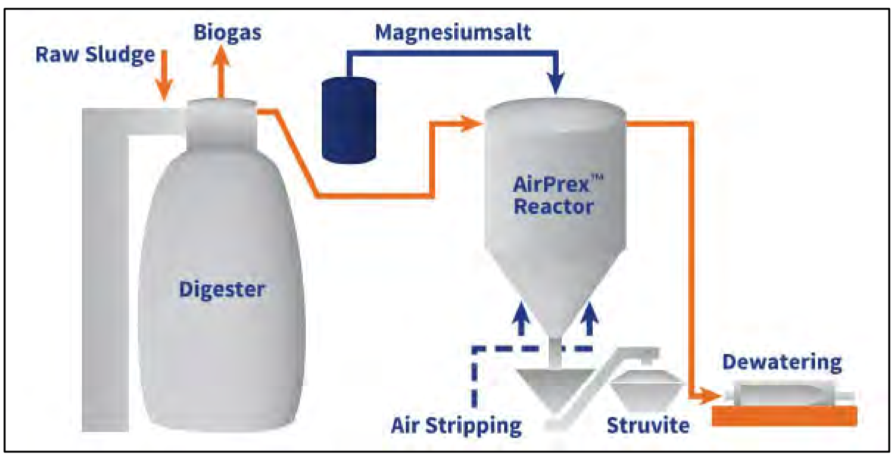


Figure 6-6: AirPrex Process Flow Diagram

Source: CNP

Figure 6-7: Struvite Produced in AirPrex Reactor, and Packaged Struvite Fertilizer Product

6.3.2.1 *Representative Centrate Treatment Technologies*

To simplify the BCE effort, a representative technology for sidestream nitrogen and struvite removal was selected as a representative technology for analysis.

For sidestream nitrogen removal, the DEMON process was selected based on its lower operating cost and footprint relative to other technologies. In addition, DEMON has a significant number of installations worldwide and in the United States. Currently, there are over 5 installations that are operational and a few under construction in the United States. For planning purposes, the footprint of a DEMON system is assumed to match Figure 6-8. In general, DEMON can be applied in a variety of different tank configurations (round, rectangular, etc.). At other utilities, DEMON was successfully adopted in existing basins to reduce the cost of installation.

Table 6-13 lists the installations of DEMON in North America as of 2015.

Table 6-13: DEMON Installation List in North America

Year	Location	Status	Drivers
2014	Chambers Creek, Pierce County, WA	Under construction	Reduce mainstream methanol demands; reduce size of aeration basins
2015	DC Water- Blue Plains, Washington, DC	Under construction	Thermal hydrolysis recycle streams with high NH_3
2016	Raleigh NRRRF	Planned installation	Digestion was a new component in solids treatment
2015	Greeley, CO	Operational	Reduce methanol demands
2012	HRSD, York River, VA	Operational	Recycle streams with high ammonia; Energy costs
2013	Orlando, FL	Operational	Reduce energy demand
2013	Alexandria, VA	Operational	
2016	Philadelphia, PA	100% review by client	
2015	Guelph, Ontaria	Operational	

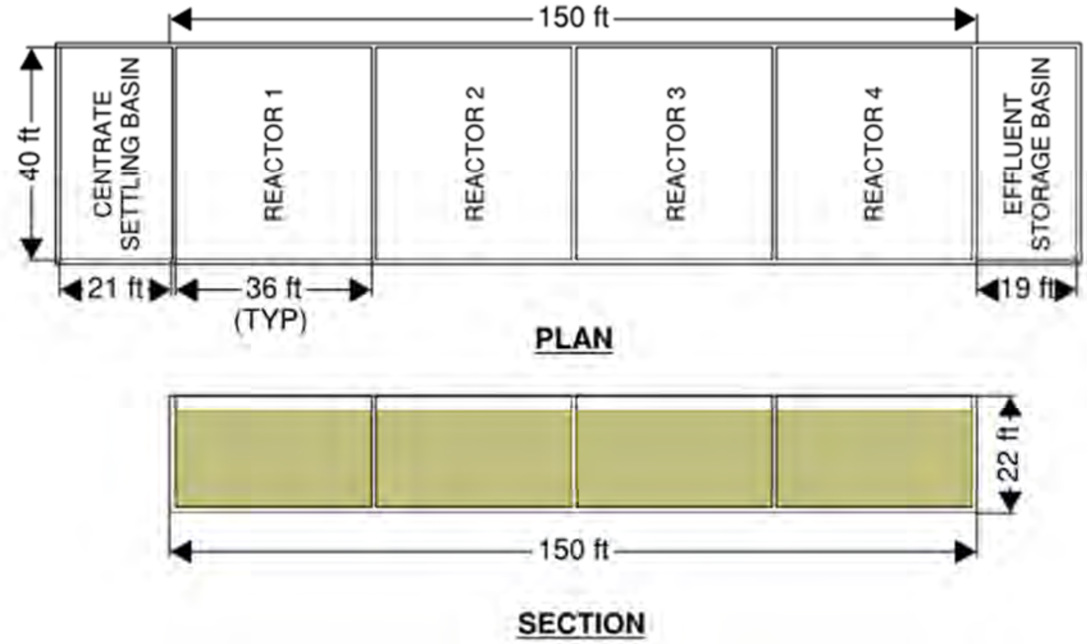


Figure 6-8: General DEMON Footprint and Required Height

For struvite removal, the AirPrex system was selected for the flexibility to either precipitate struvite in the digested sludge prior to dewatering or to recover struvite struvite for sale. AirPrex induces struvite formation in digested sludge prior to dewatering. Struvite can either be precipitated and left in the digested sludge or removed for recovery and sale. When left in the digested sludge, the struvite can enhance the nutrient value of the biosolids.

Ostara is considered by many to be the leading manufacturer in struvite recovery. For this evaluation, Ostara was not selected as the representative technology because it requires the WASSTRIP process to effectively prevent struvite formation in the dewatering equipment. While the WASSTRIP process may prove to be effective if appropriate field testing and pilot-scale demonstrations are performed, it was considered an unacceptable risk to assume its effectiveness and include it within this BCE. The Ostara process also requires additional equipment, because it always harvests struvite. This increases the O&M and capital costs creating a less favorable scenario for sidestream phosphorus removal. The Ostara reactor does have a higher struvite recovery efficiency than AirPrex, thus if struvite harvesting and sale is shown to improve the sidestream phosphorus removal alternatives then an additional BCE should be undertaken to assess the selection of AirPrex and Ostara assuming appropriate field testing is also performed.

For planning purposes, the footprint of an AirPrex system is assumed to match Figure 6-9.

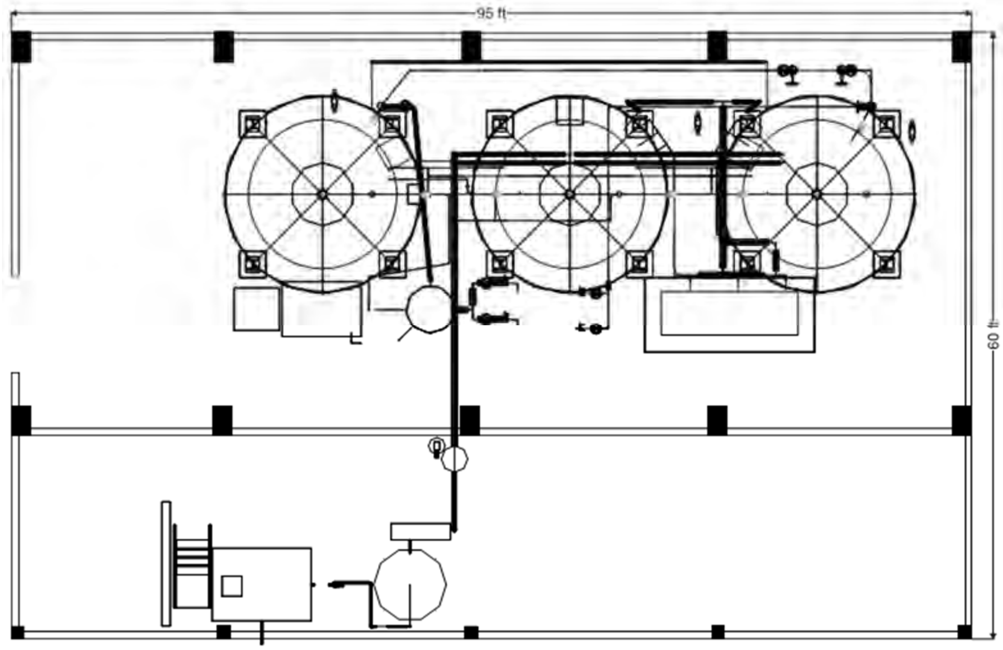


Figure 6-9: Typical AirPrex Configuration and Footprint

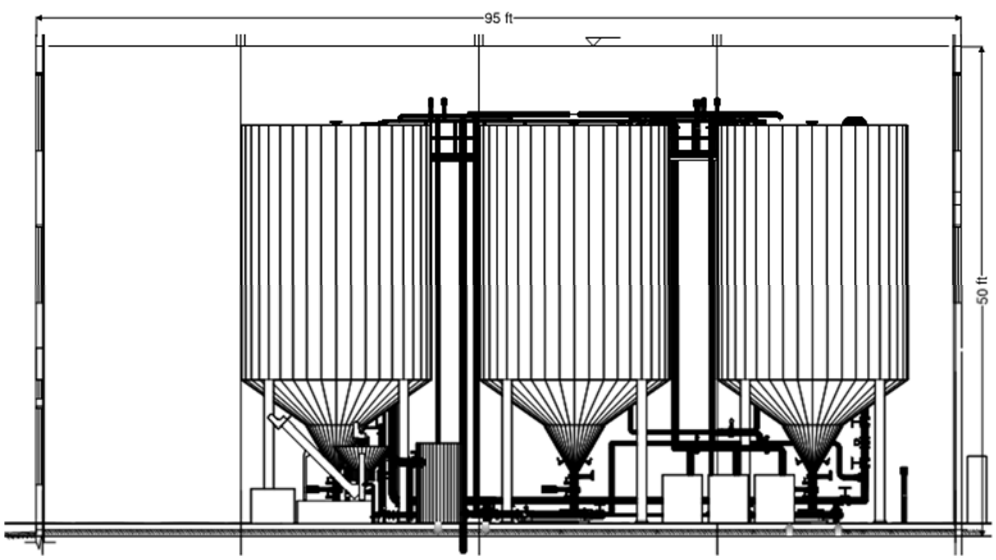


Figure 6-10: Typical AirPrex Section

Centrate equalization was sized to store centrate during an 8-hour dewatering shift and return centrate to the plant over a 24-hour period. The following schematic illustrates the footprint of a centrate equalization considered for this BCE.

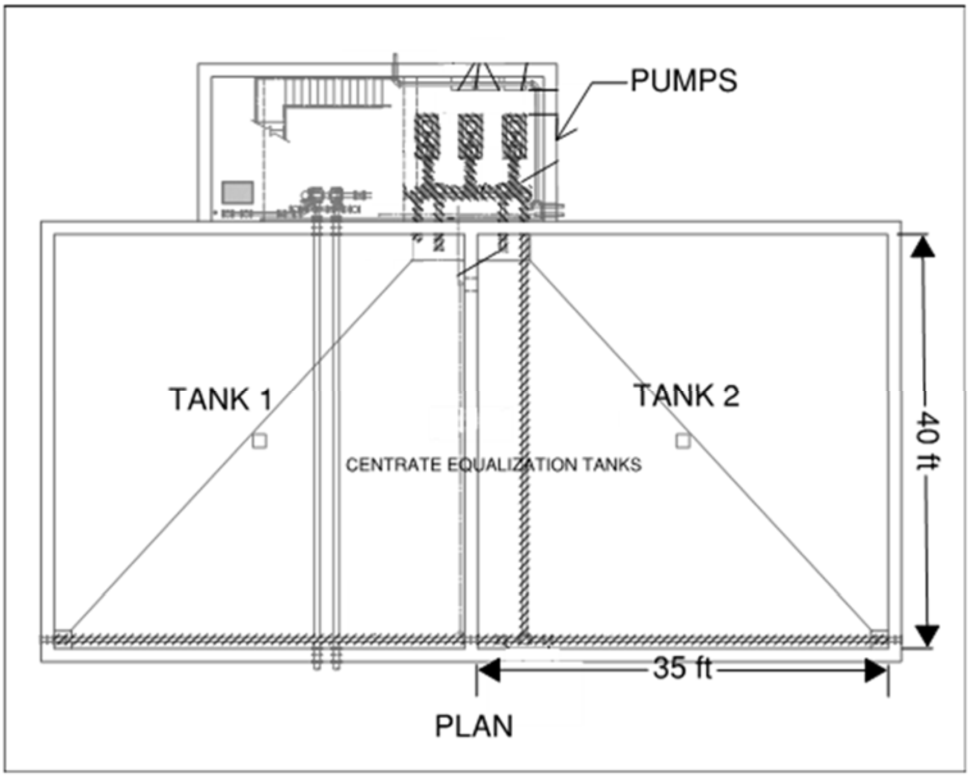


Figure 6-11: Centrate Equalization Tanks and Pump Station Footprint

6.3.3 RP-1 Alternatives

Several alternatives were considered for centrate handling at RP-1. This section describes these alternatives in more detail.

Discharge Centrate to NRW Line

Currently RP-1 discharges centrate to the NRW line. A usage fee is assessed for this service based on the quantity and quality of centrate discharged and a constant O&M and ___ (CIP) fee. The rate structure established in the current agreement between IEUA and the County Sanitation Districts of Los Angeles County for fiscal year 2015–16 was assumed to apply for calendar year 2016, with an assumed escalation rate applied for each subsequent year. It was assumed that IEUA had already paid for the necessary upfront costs for the maximum capacity units (CUs) for discharge and would not need to procure more CUs. This alternative consists of the lowest capital expenditures because centrate treatment or equalization is not required.

Recycling Centrate Back to RP-1 Liquids Treatment

Centrate from RP-1 can recycle to the secondary liquid process for treatment. Recycling centrate to the secondary process will increase the nitrogen load and thus require greater aeration volume for nitrification, higher aeration air requirements, and potentially supplemental carbon requirements for denitrification, which was assumed to be methanol requirements for this analysis. Recycling centrate back to the liquids process will require some equalization to minimize the impact of dewatering schedule on the plant load. For the purpose of this study, it is assumed that dewatering will occur daily over an 8-hour shift, and centrate will be equalized to allow storage and return of the centrate to the liquids process over 24 hours.

Separate Treatment of Centrate at RP-1

Separate treatment of centrate can be achieved by sidestream treatment with the DEMON process. DEMON is assumed to remove 85 percent of the ammonia load in the centrate. For struvite removal, AirPrex was used for this analysis. AirPrex is capable of removing 90 percent of the phosphorus load in the digested sludge. It should be noted that AirPrex is not a centrate treatment process but it achieves phosphorus removal and provides struvite control. For both DEMON and AirPrex, equalization of the centrate is required to manage the size and cost of the centrate treatment process and reduce impact on the liquid stream process. For the purpose of this study, it is assumed that dewatering will occur daily over an 8-hour shift, and centrate will be equalized to allow storage and return of the centrate to the separate treatment process over 24 hours.

Transfer Centrate from RP-1 to RP-5 with Combined Treatment

At RP-1, the capability exists to transfer centrate into a gravity sewer line to the RP-5 headworks and the centrate will subsequently be treated in the secondary system at RP-5. The volume of centrate transfer to RP-5 will depend on the dewatering schedule. To manage the nitrogen load at RP-5 associated with the centrate, it is assumed that centrate equalization will be provided for this alternative. It is assumed that dewatering will occur daily over an 8-hour shift, and centrate will be equalized to allow storage and return of the centrate to RP-5 over 24 hours.

6.3.4 RP-5 Alternatives

Several alternatives were considered for centrate handling at RP-5. This section describes these alternatives in more detail.

Discharge Centrate to IEBL Line

Centrate from the new solids process at RP-5 can be connected to the IEBL line for disposal. Similar to the NRW line, a usage fee is assessed for this service based on centrate quantity and quality and a constant capacity and CIP fee. The rate structure established in the current resolution by IEUA for fiscal year 2015–16 was assumed to apply for calendar year 2016, with an assumed escalation rate applied for each subsequent year. It was assumed that IEUA had already paid for the necessary upfront costs for the maximum CUs for discharge and any application and permitting fees and would not need to procure more CUs. This alternative consists of the lowest capital expenditures because centrate treatment or equalization is not required.

Recycling Centrate to RP-5 Liquids Treatment

Centrate generated at RP-5 can be recycled to the secondary liquid process for treatment. This is similar to the current operation as the recycle flows generated at RP-2 are routed to RP-5 for treatment. Compared to the option of sending the centrate to IEBL, recycling centrate back to the liquids process will require some equalization to minimize the impact of dewatering schedule on the plant load. For the purpose of this study, it is assumed that dewatering will occur daily over an 8-hour shift, and centrate will be equalized to allow storage and return of the centrate to the liquids process over 24 hours.

Separate Treatment of Centrate at RP-5

Separate treatment of centrate includes sidestream treatment with DEMON and AirPrex. As noted above, AirPrex is not a centrate treatment process but is included as an option for this alternative as it achieves some similar objectives and also provides struvite control. Separate treatment of centrate will also require some equalization of centrate to manage the size and cost of the centrate treatment process. For the purpose of this study, it is assumed that dewatering will occur daily over an 8-hour shift, and centrate will be equalized to allow storage and return of the centrate to the separate treatment process over 24 hours.

6.4 ALTERNATIVES SCREENING

The previously listed alternatives or a combination of these alternatives will provide the best opportunity for centrate handling at RP-1 and RP-5. The IEUA includes a complex system with several treatment plants: CCWRF, RP-1, RP-2, RP-4, and RP-5. Each treatment plant has specific capacity limitations and different plans for expansion or decommissioning. As such, the most attractive centrate handling alternatives or combination of alternatives at RP-1 and RP-5 must account for the respective flows, loads, and capacities of each reclamation plant. This section summarizes combination of centrate handling alternatives based on the projected flows, loads, and timing of planned capacity expansions at the various reclamation facilities.

6.4.1 Screening

The current understanding of the flows and projected process capacities at RP-1 and RP-5 is summarized in Figure 6-12 and Figure 6-13. Based on these flows and projected capacities, several alternatives for centrate handling at RP-1 can be developed.

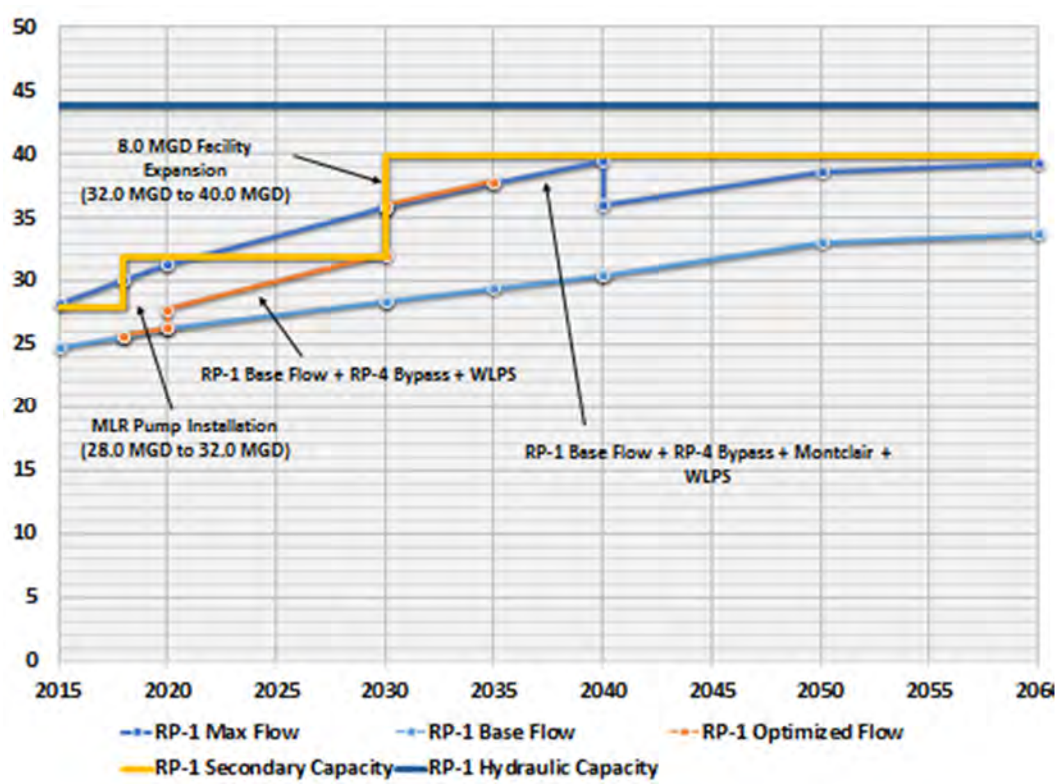


Figure 6-12: RP-1 Influent Flow and Treatment Capacity

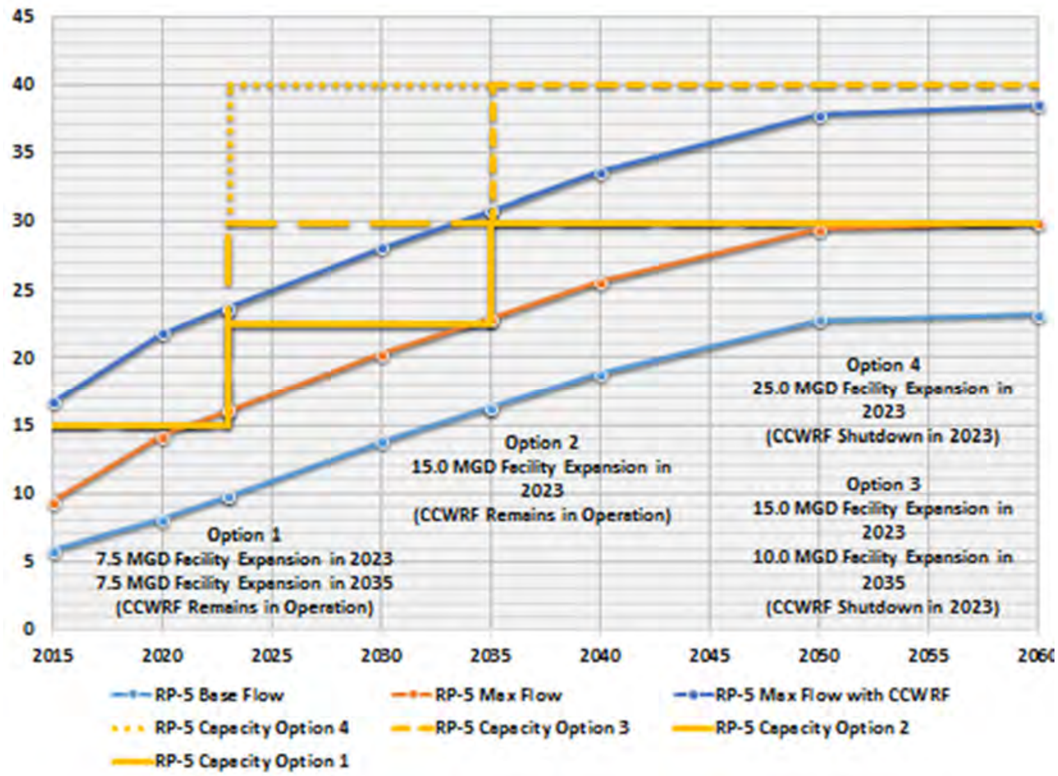


Figure 6-13: RP-5 Influent Flow and Treatment Capacity

Centrate Handling Alternatives at RP-1

This section describes centrate handling alternatives at RP-1.

Alternative 1

At RP-1, the current practice of transferring centrate to the NRW line can continue indefinitely (though there are some risks to be considered). This alternative assumes centrate will be transferred from RP-1 to the NRW line for the duration of the evaluation. Figure 6-14 shows a flow forecast for RP-1 Alternative 1.

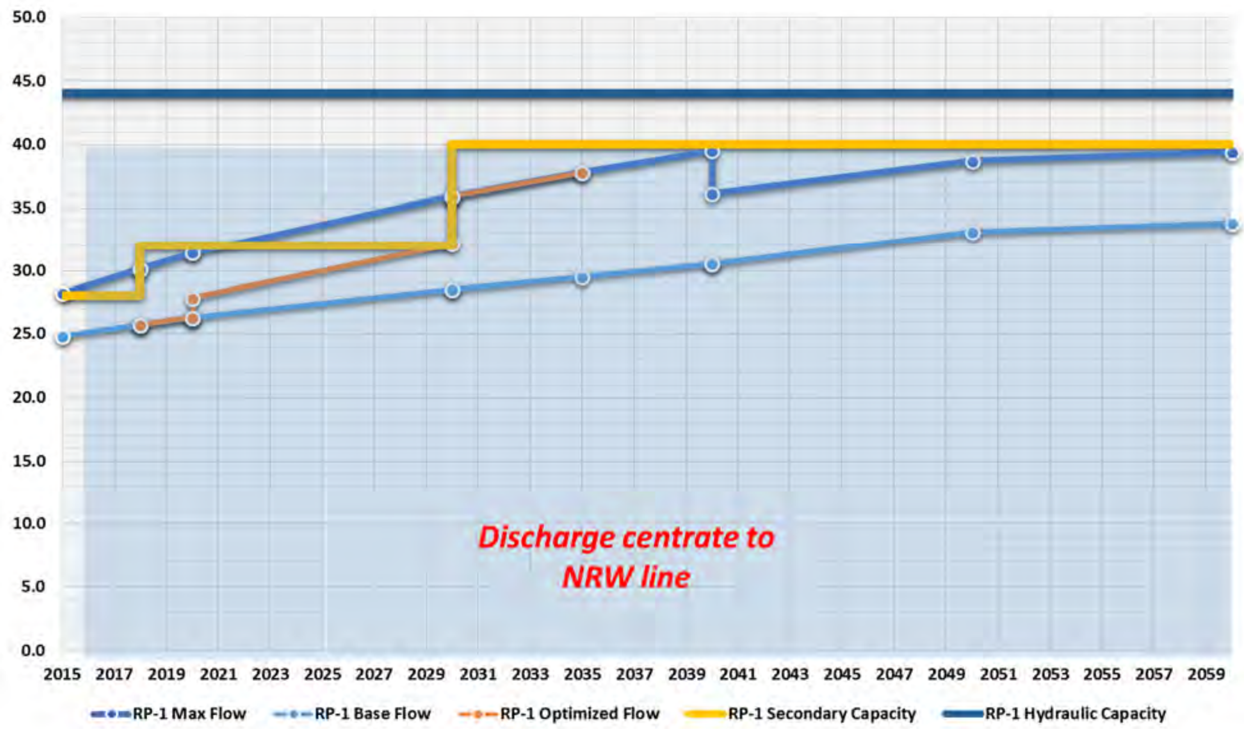


Figure 6-14: RP-1 Flow Forecast (mgd); RP-1 Alternative 1: Discharge to the NRW Line

Alternative 2

A planned expansion at RP-1 will occur in 2030 and, during this expansion, separate centrate treatment capacity can be designed as DEMON to allow centrate treatment. Prior to 2030, it is not anticipated that RP-1 will have sufficient capacity to treat centrate and, during that period, centrate can be returned to the NRW line. While the DEMON process will remove most of the nitrogen load in centrate, a small fraction, approximately 10 to 20 percent, will be returned to the secondary process as nitrate. While this will not increase aeration demand, the secondary denitrification process should be designed to accommodate this load. The DEMON system would be designed for the centrate flows and loads corresponding to the projected 2045 plant influent flows at RP-1 and RP-4. Figure 6-15 shows a flow forecast for RP-1 Alternative 2.

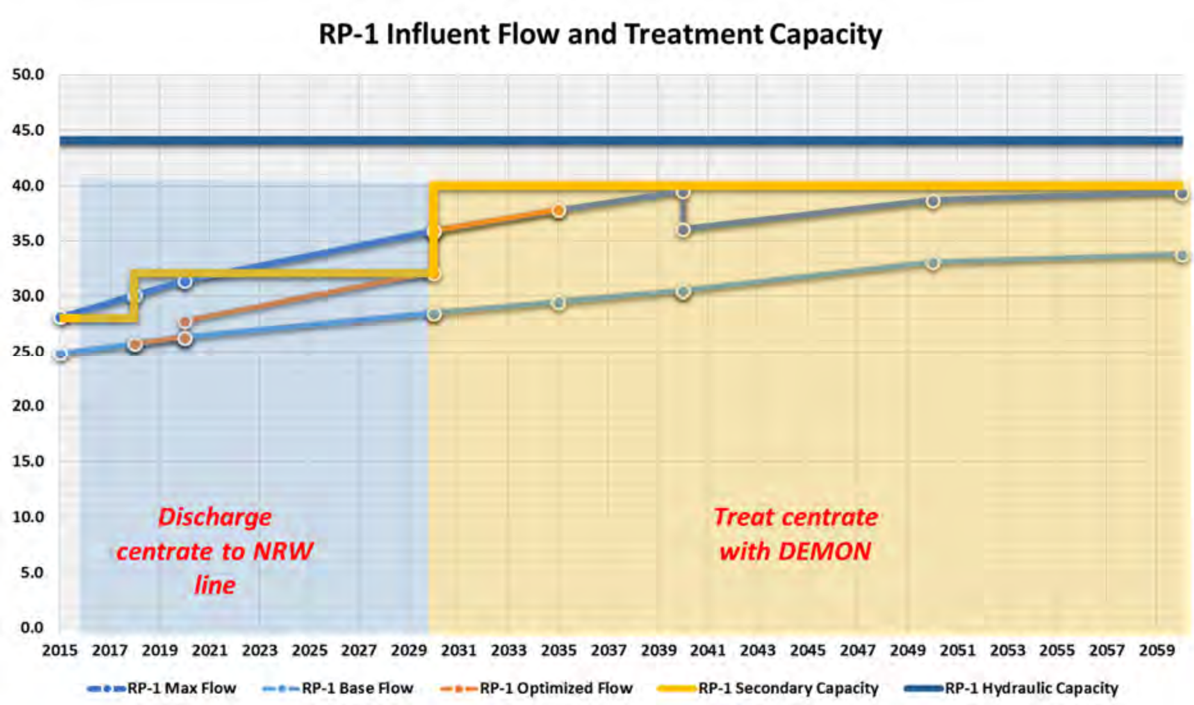


Figure 6-15: RP-1 Flow Forecast (mgd), RP-1 Alternative 2: Treat Centrate with DEMON after 2030

Alternative 3

A planned expansion at RP-1 will occur in 2030 and, during this expansion, separate centrate treatment capacity can be designed with AirPrex. Prior to 2030, centrate can be returned to the NRW line. The AirPrex system would be designed to remove some nitrogen and all struvite. Currently struvite accumulates at RP-1 at the dewatering process, and struvite accumulation is managed by addition of a chemical designed to control the precipitation of struvite. Removal of struvite with AirPrex will reduce operating costs associated with struvite cleaning chemicals. In addition, AirPrex will remove approximately 25 percent of the nitrogen load. The remaining nitrogen load in the centrate will be recycled to RP-1 liquids process, and the secondary system should be designed to accommodate this additional load. The AirPrex system would be designed for the digested sludge flows and loads corresponding to the projected 2045 plant influent flows at RP-1 and RP-4. Figure 6-16 shows a flow forecast for RP-1 Alternative 3.

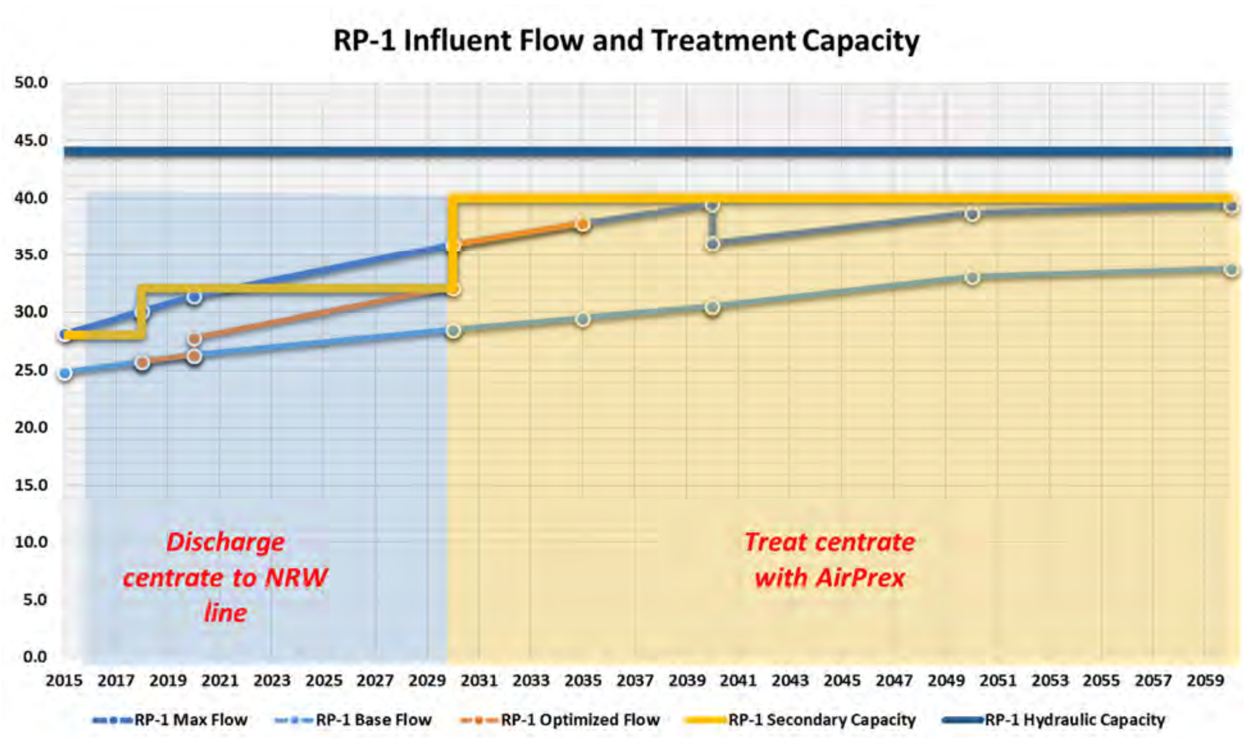


Figure 6-16: RP-1 Flow Forecast (mgd), RP-1 Alternative 3: Treat Centrate with AirPrex after 2030

Alternative 4

A planned expansion at RP-1 will occur in 2030 and, during this expansion, separate centrate treatment capacity can be designed with both DEMON and AirPrex. DEMON and AirPrex will provide the combined advantages presented with Alternatives 2 and 3. The systems would be designed for the centrate and digested sludge flows and loads corresponding to the projected 2045 plant influent flows at RP-1 and RP-4. Prior to 2030, centrate will continue to be discharged to the NRW line. Figure 6-17 shows a flow forecast for RP-1 Alternative 4.

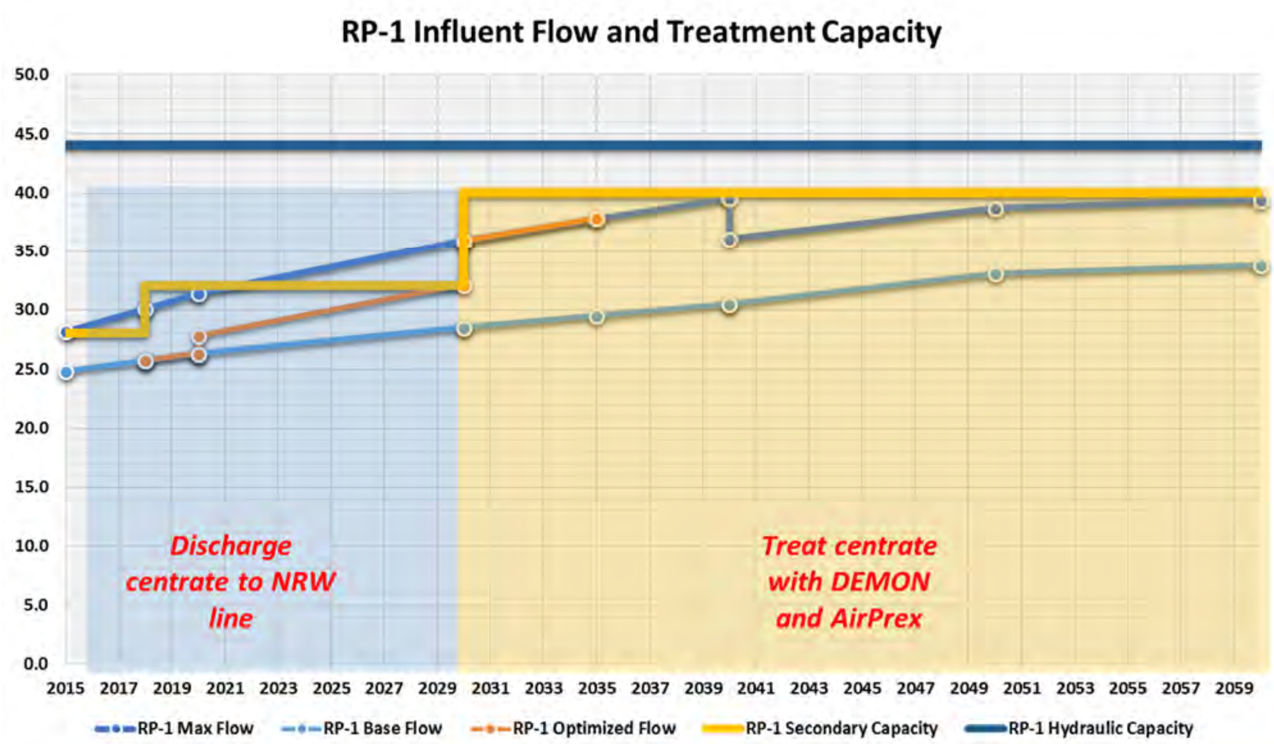


Figure 6-17: RP-1 Flow Forecast (mgd), RP-1 Alternative 4: Treat Centrate with DEMON and AirPrex after 2030

Alternative 5

A planned expansion at RP-1 will occur in 2030 and, during this expansion, additional secondary system capacity can be designed and installed to allow centrate to be recycled back to the plant. Prior to 2030, it is not anticipated that RP-1 will have sufficient capacity to treat centrate, and during that period, centrate will continue to be discharged to the NRW line. Figure 6-18 shows a flow forecast for RP-1 Alternative 5.

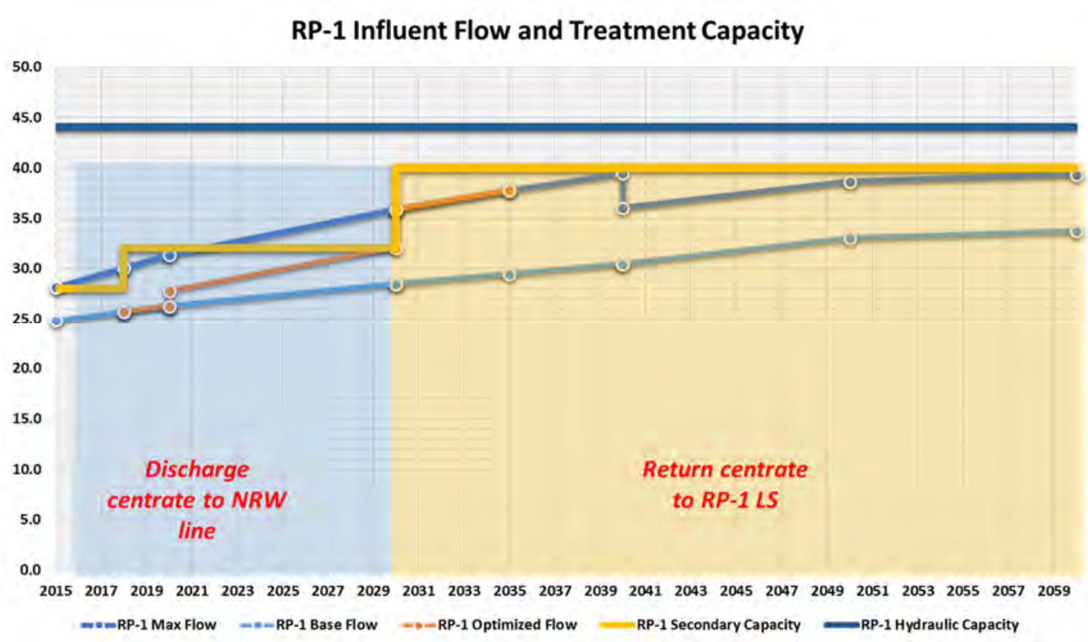


Figure 6-18: RP-1 Flow Forecast (mgd), RP-1 Alternative 5: Return Centrate to RP-1 Liquids Stream after 2030

Alternative 6

A planned expansion at RP-5 will occur in 2022 and, during this expansion, additional secondary system capacity can be designed and installed to allow centrate to be transferred from RP-1 to RP-5. Transferring centrate to RP-5 will require the secondary process at RP-5 to be designed to handle the increased nitrogen load. Also, based on the influent and centrate characteristics, it is anticipated that RP-5 will require methanol addition to process the centrate from both RP-1 and RP-5. Prior to 2022, it is assumed that centrate will continue to be discharged to the NRW line. Figure 6-19 shows a flow forecast for RP-1 Alternative 6.

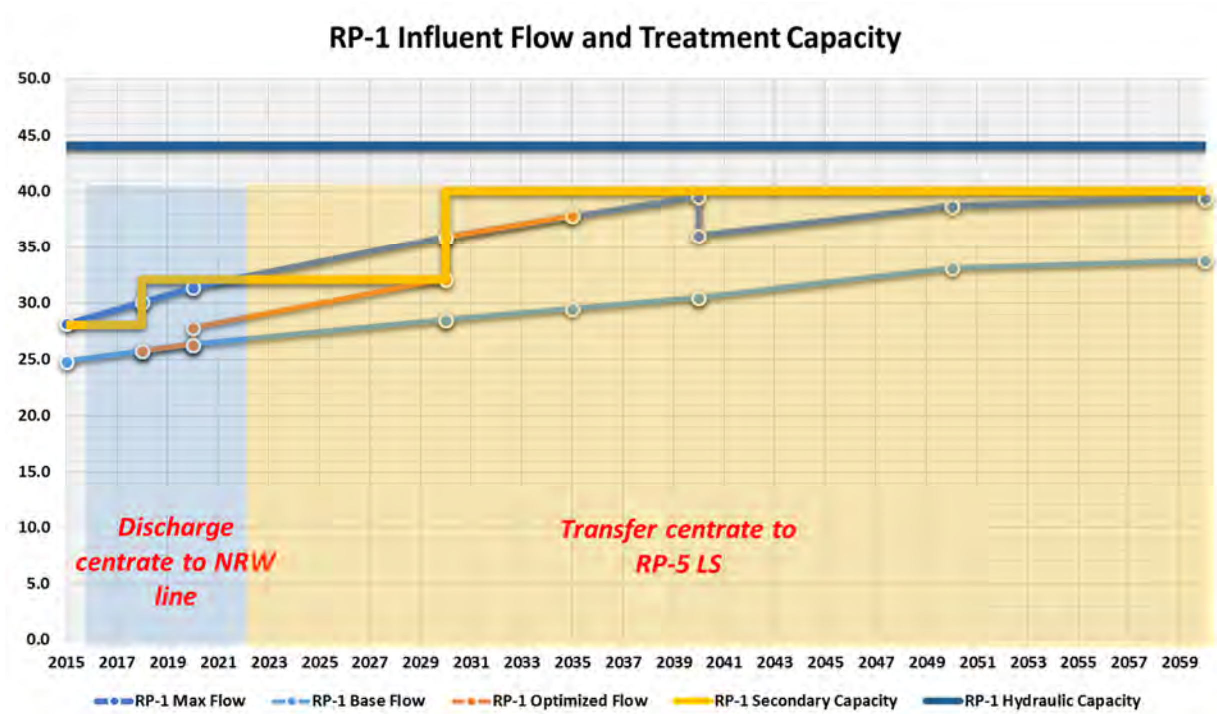


Figure 6-19: RP-1 Flow Forecast (mgd), RP-1 Alternative 6: Centrate Transfer to RP-5 after 2022

Alternative 7

A planned expansion at RP-5 will occur in 2022 and, initially after this expansion, RP-5 will have excess secondary capacity to process centrate. Prior to 2022, it is assumed that centrate will continue to be discharged to the NRW line. After the 2022 RP-5 expansion, centrate can be transferred to RP-5 until 2030, when RP-1 expansion is anticipated. During the RP-1 expansion, separate centrate treatment capacity can be designed as DEMON to allow centrate treatment. Figure 6-20 shows a flow forecast for RP-1 Alternative 7.

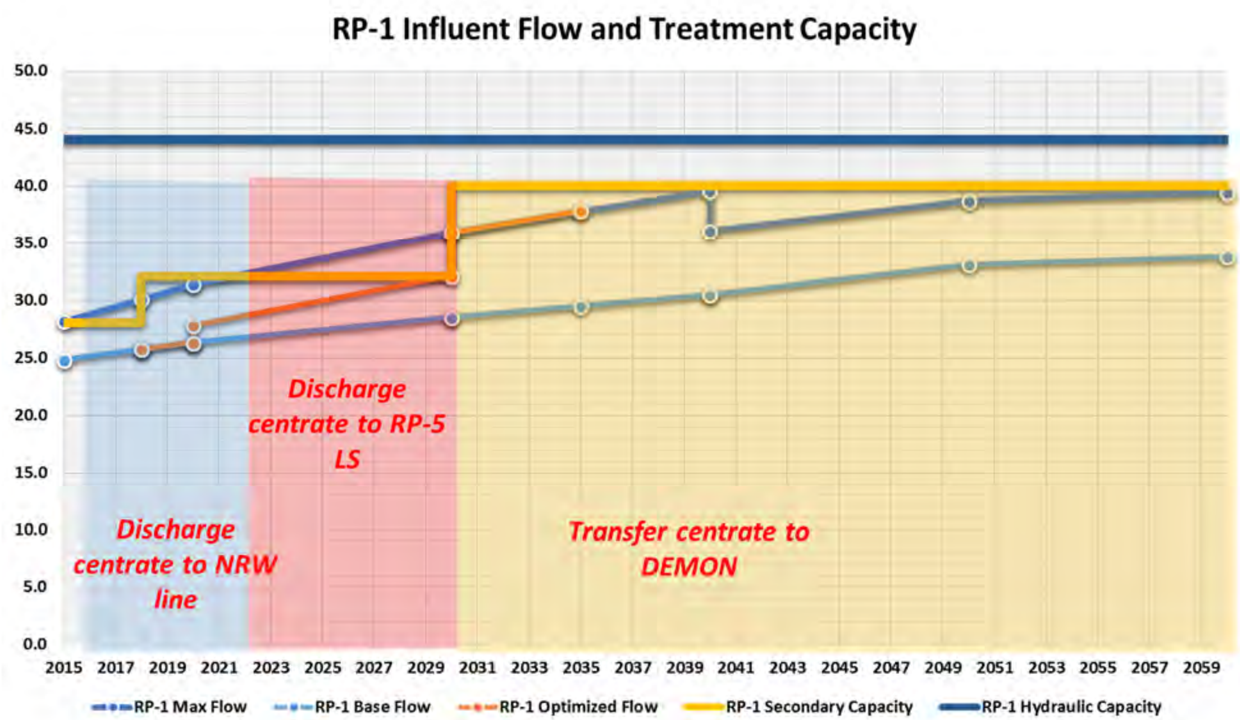


Figure 6-20: RP-1 Flow Forecast (mgd), RP-1 Alternative 7: Centrate Transfer to RP-5 after 2022 and to RP-1 DEMON after 2030

Alternative 8

A planned expansion at RP-5 will occur in 2022 and, initially after this expansion, RP-5 will have excess secondary capacity to process centrate. Prior to 2022, it is assumed that centrate will continue to be discharged to the NRW line. After the 2022 RP-5 expansion, centrate can be transferred to RP-5 until 2030, when RP-1 expansion is anticipated. During the RP-1 expansion, separate centrate treatment capacity can be designed as AirPrex to allow centrate treatment. Figure 6-21 shows a flow forecast for RP-1 Alternative 8.

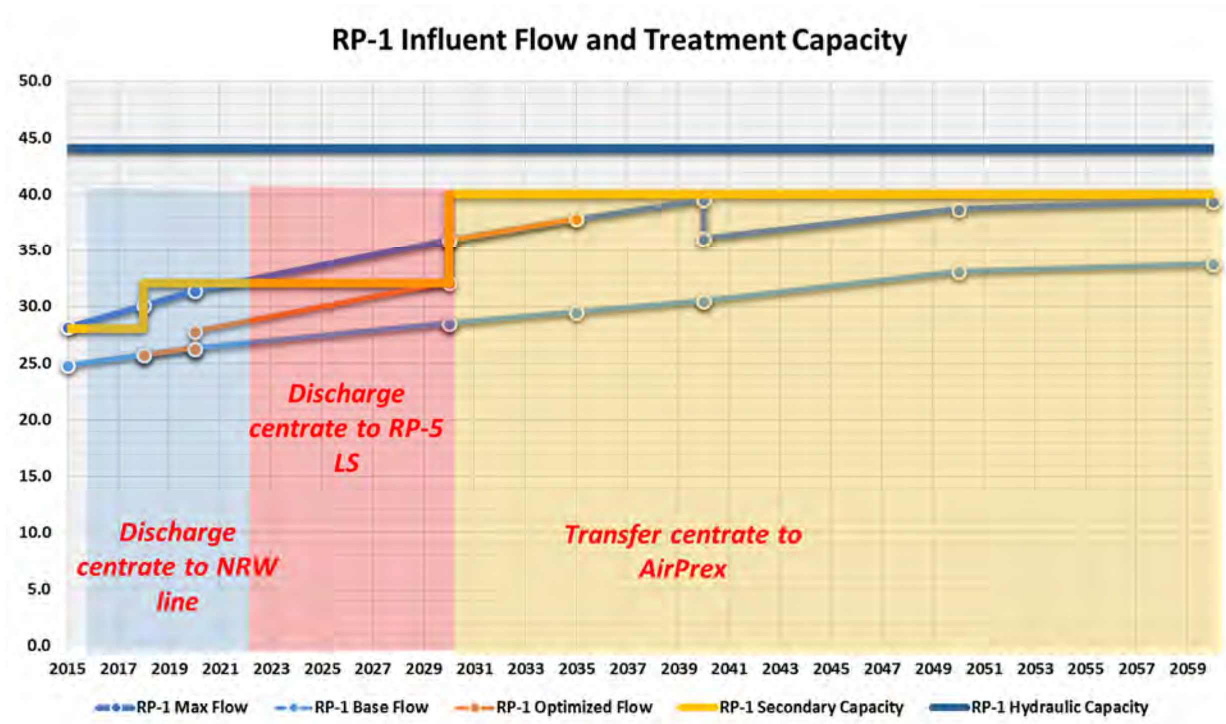


Figure 6-21: RP-1 Flow Forecast (mgd), RP-1 Alternative 8: Centrate Transfer to RP-5 after 2022 and RP-1 AirPrex after 2030

Alternative 9

A planned expansion at RP-5 will occur in 2022 and, initially after this expansion, RP-5 will have excess secondary capacity to process centrate. Prior to 2022, it is assumed that centrate will continue to be discharged to the NRW line. After the 2022 RP-5 expansion, centrate can be transferred to RP-5 until 2030, when RP-1 expansion is anticipated. During the RP-1 expansion, separate centrate treatment capacity can be designed as DEMON and AirPrex to allow centrate treatment. Figure 6-22 shows a flow forecast for RP-1 Alternative 9.

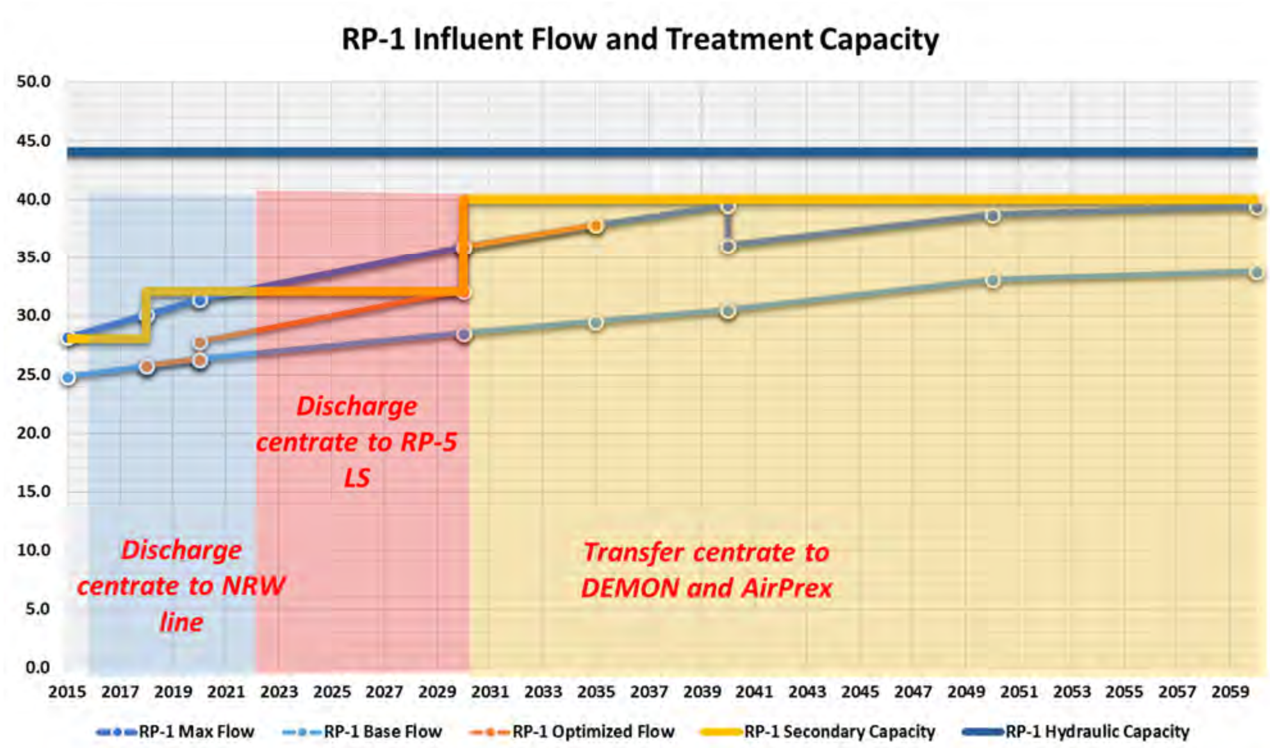


Figure 6-22: RP-1 Flow Forecast (mgd), RP-1 Alternative 9: Centrate Transfer to RP-5 after 2022 and RP-1 DEMON and AirPrex after 2030

Alternative 10

A planned expansion at RP-1 will occur in 2030, and it is anticipated that footprint will be constrained at the site. Prior to 2030, it is not anticipated that RP-1 will have sufficient capacity to treat centrate and, during that period, centrate will continue to be discharged to the NRW line. Further, this alternative assumes that expansion of RP-1 will not be able to accommodate the additional load associated with centrate recycle. Therefore, it is planned that centrate will be transferred to RP-5 after 2030. Figure 6-23 shows a flow forecast for RP-1 Alternative 10.

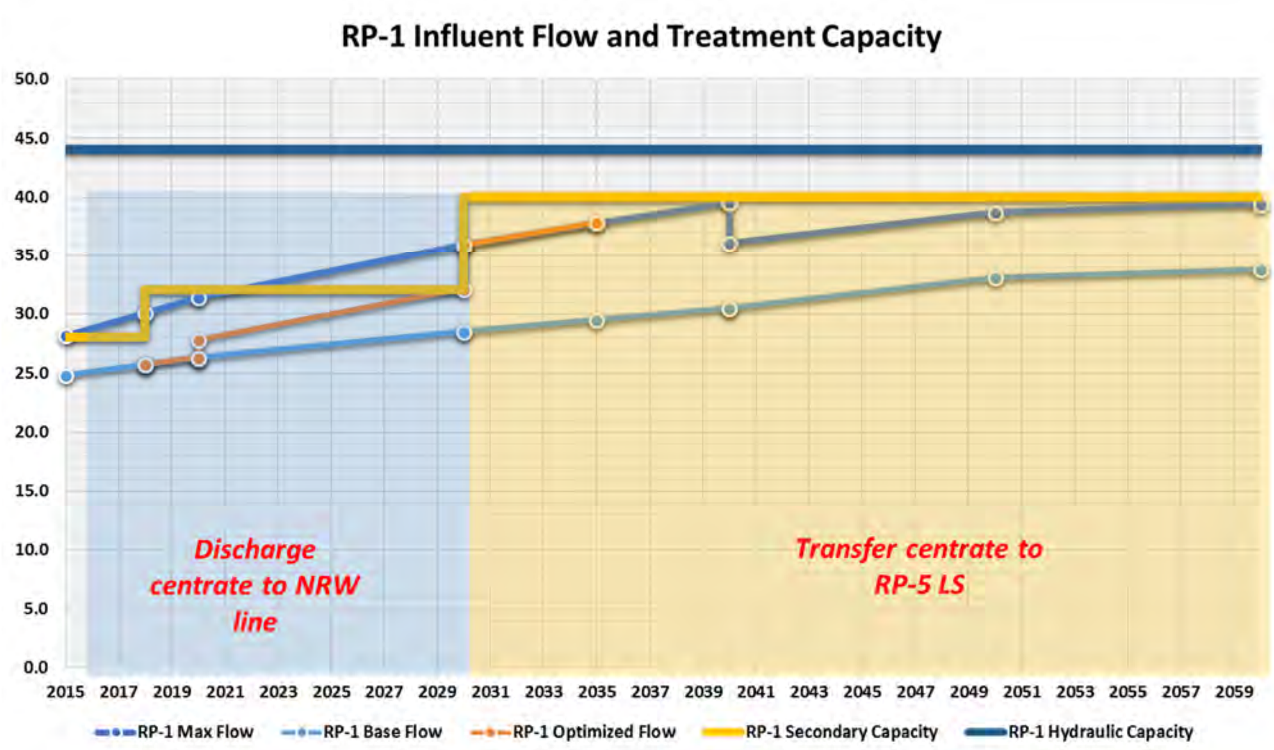


Figure 6-23: RP-1 Flow Forecast (mgd), RP-1 Alternative 10: Centrate Transfer to RP-5 after 2030

Alternative 11

A planned expansion at RP-5 will occur in 2022 and, initially after this expansion, RP-5 will have excess secondary capacity to process centrate. Prior to 2022, it is assumed that centrate will continue to be discharged to the NRW line. After the 2022 RP-5 expansion, centrate can be transferred to RP-5 until 2030, when RP-1 expansion is anticipated. During the RP-1 expansion, additional secondary capacity can be designed into RP-1 to process centrate. While RP-5 will have capacity to process the additional centrate from RP-1 from 2022 to 2030, it is anticipated that methanol addition at RP-5 will be required. Figure 6-24 shows a flow forecast for RP-1 Alternative 11.

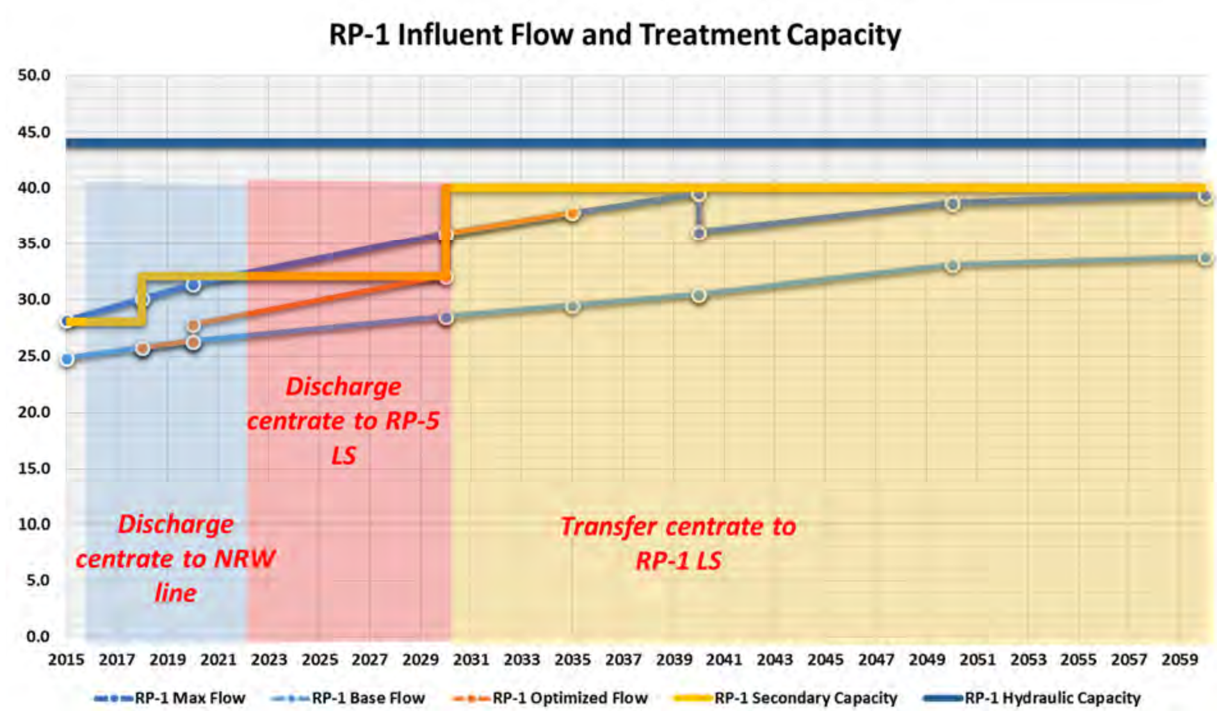


Figure 6-24: RP-1 Flow Forecast (mgd), RP-1 Alternative 11: Centrate Transfer to RP-5 before 2022 and RP-1 after 2030

Centrate Handling Alternatives at RP-5

This section describes centrate handling alternatives at RP-5.

Alternative 1

Centrate from solids processing at RP-2 is currently transferred to the RP-5 headworks along with other recycle flows from RP-2. Alternative 1 assumes this centrate will continue to be sent to RP-5 until the 2022 plant expansion. After construction and startup of the solids processing facilities at RP-5, centrate from RP-5 can be routed to the IEBL. With this approach, no additional equipment is required for centrate handling. Also, the RP-5 secondary system does not need to be expanded to accommodate the additional recycle load. Figure 6-25 shows a flow forecast for RP-5 Alternative 1.

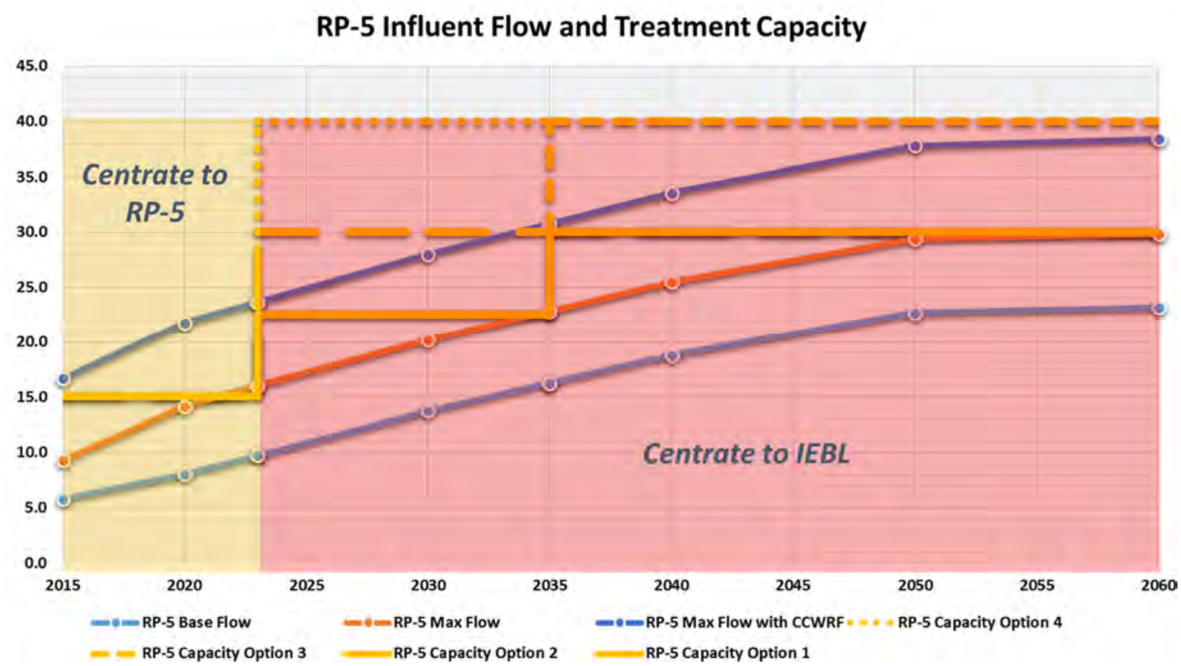


Figure 6-25: RP-5 Flow Forecast (mgd); RP-5 Alternative 1: Discharge to the IEBL

Alternative 2

Centrate from solids processing at RP-2 is currently transferred to the RP-5 headworks along with other recycle flows from RP-2. Alternative 2 assumes this centrate will continue to be transferred to RP-5 until construction of the solids processing at RP-5. After startup of the solids processing facilities at RP-5, centrate from RP-5 can be recycled back to RP-5 for treatment. The RP-5 secondary system will need to be expanded to accommodate the additional recycle load. Centrate equalization would be provided to allow daily operation of dewatering over an 8-hour shift. The equalization volume would be sized to return this centrate to the RP-5 liquids stream over a 24-hour period. Figure 6-26 shows a flow forecast for RP-5 Alternative 2.

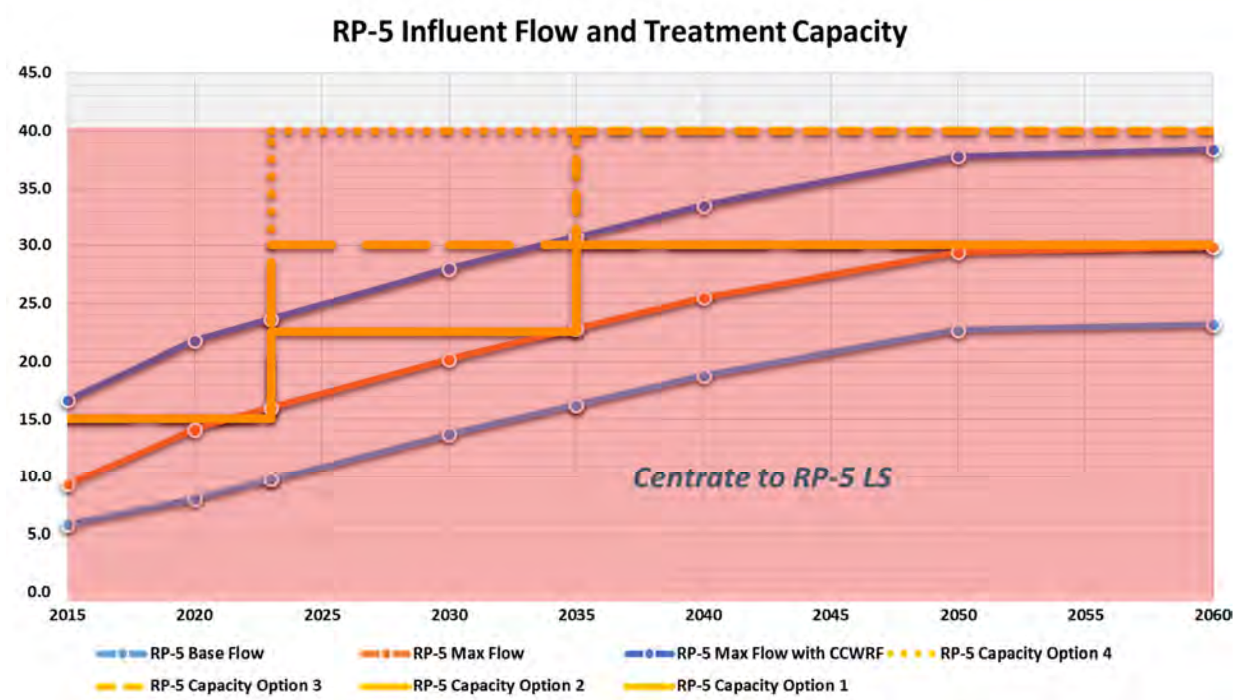


Figure 6-26: RP-5 Flow Forecast (mgd); RP-5 Alternative 2: Centrate Recycle to RP-5

Alternative 3

Centrate from solids processing at RP-2 is currently transferred to the RP-5 headworks along with other recycle flows from RP-2. Alternative 3 assumes this centrate will continue to be transferred to RP-5 until construction of the solids processing at RP-5, and the expansion at RP-5 would include DEMON sidestream treatment for centrate. After startup of the solids processing facilities at RP-5 in 2022, centrate from RP-5 will be treated with DEMON. While the DEMON process will remove most of the nitrogen load in centrate, a small fraction, approximately 10 to 20 percent, will be returned to the secondary process as nitrate. While this will not increase aeration demand, the secondary denitrification process should be designed to accommodate this load. The DEMON system would be designed for centrate load corresponding to 40 mgd of plant flow capacity. Figure 6-27 shows a flow forecast for RP-5 Alternative 3.

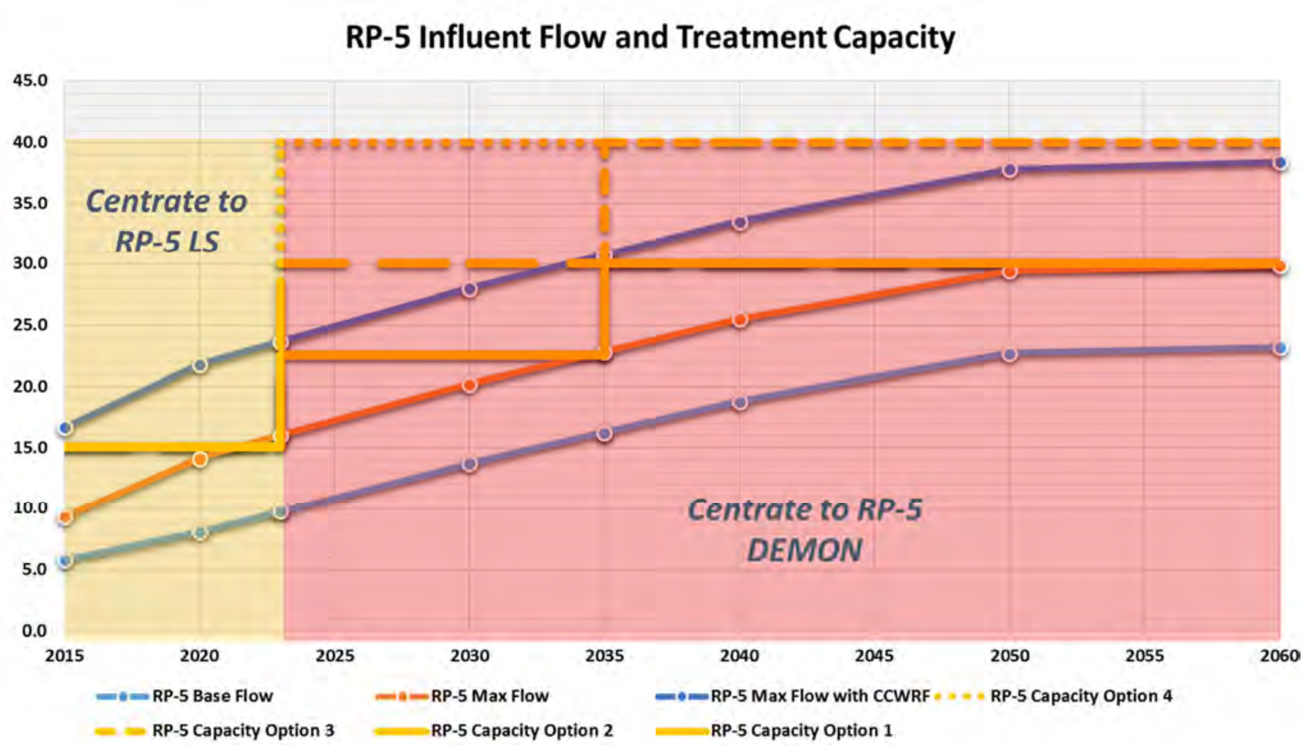


Figure 6-27: RP-5 Flow Forecast (mgd); RP-5 Alternative 3: Centrate to RP-5 DEMON

Alternative 4

Centrate from solids processing at RP-2 is currently transferred to the RP-5 headworks. Alternative 4 assumes this centrate will continue to be transferred to RP-5 until construction of the solids processing at RP-5, and the expansion at RP-5 would include AirPrex sidestream treatment for centrate. After startup of the solids processing facilities at RP-5 in 2022, centrate from RP-5 will be treated with AirPrex. The AirPrex system would be designed to remove some nitrogen and all struvite. Currently struvite accumulates at RP-1 at the dewatering process, and struvite accumulation is managed by addition of a chemical designed to control the precipitation of struvite. It is assumed a similar condition will exist at RP-5, and the removal of struvite with AirPrex will reduce operating costs associated with struvite cleaning chemicals. In addition, AirPrex will remove approximately 8 percent of the nitrogen load. The remaining nitrogen load in the centrate will be recycled to the RP-5 liquids process, and the secondary system should be designed to accommodate this additional load. The AirPrex system would be designed for digested sludge loads corresponding to 40 mgd of plant flow capacity. Figure 6-28 shows a flow forecast for RP-5 Alternative 4.

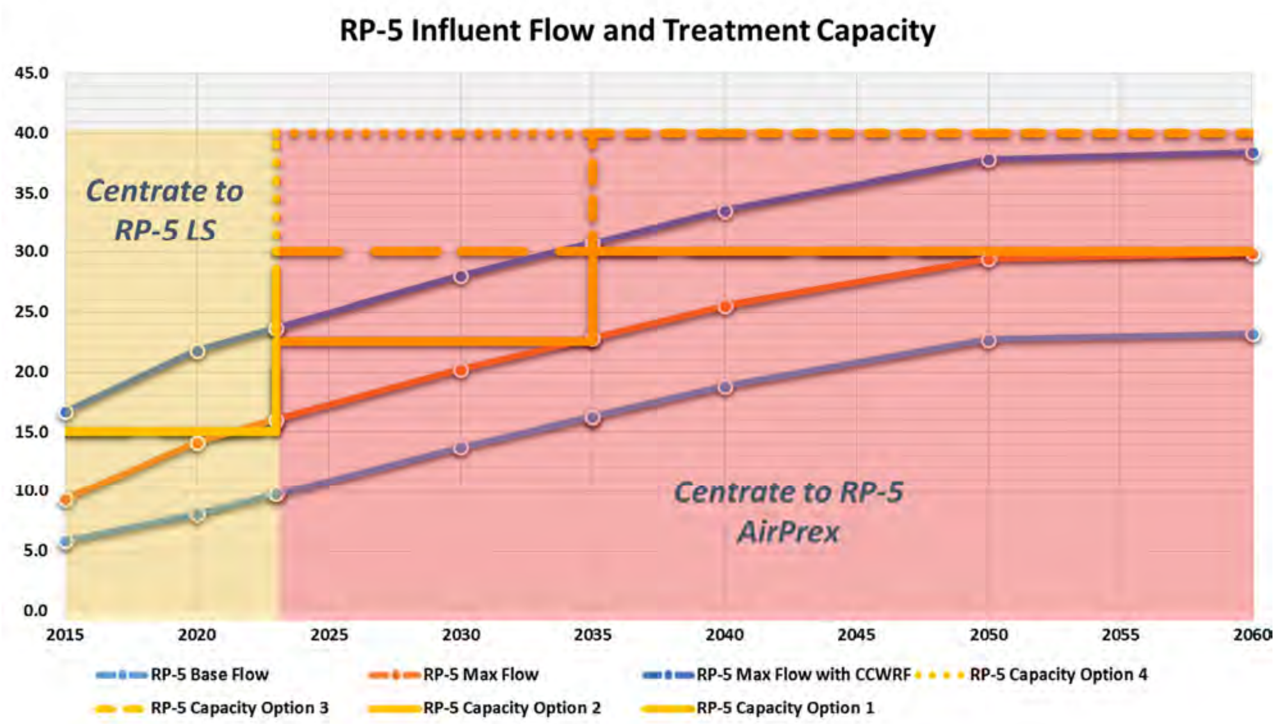


Figure 6-28: RP-5 Flow Forecast (mgd); RP-5 Alternative 4: Centrate to RP-5 AirPrex

Alternative 5

Centrate from solids processing at RP-2 is currently transferred to the RP-5 headworks. Alternative 4 assumes this centrate will continue to be transferred to RP-5 until construction of the solids processing at RP-5, and the expansion at RP-5 would include both DEMON and AirPrex sidestream treatment for centrate. After startup of the solids processing facilities at RP-5 in 2022, centrate from RP-5 will be treated with DEMON and AirPrex. DEMON and AirPrex will provide the combined advantages presented with Alternatives 3 and 4. These systems would be designed to accommodate the plant flow capacity of 40 mgd. Figure 6-29 shows a flow forecast for RP-5 Alternative 5.

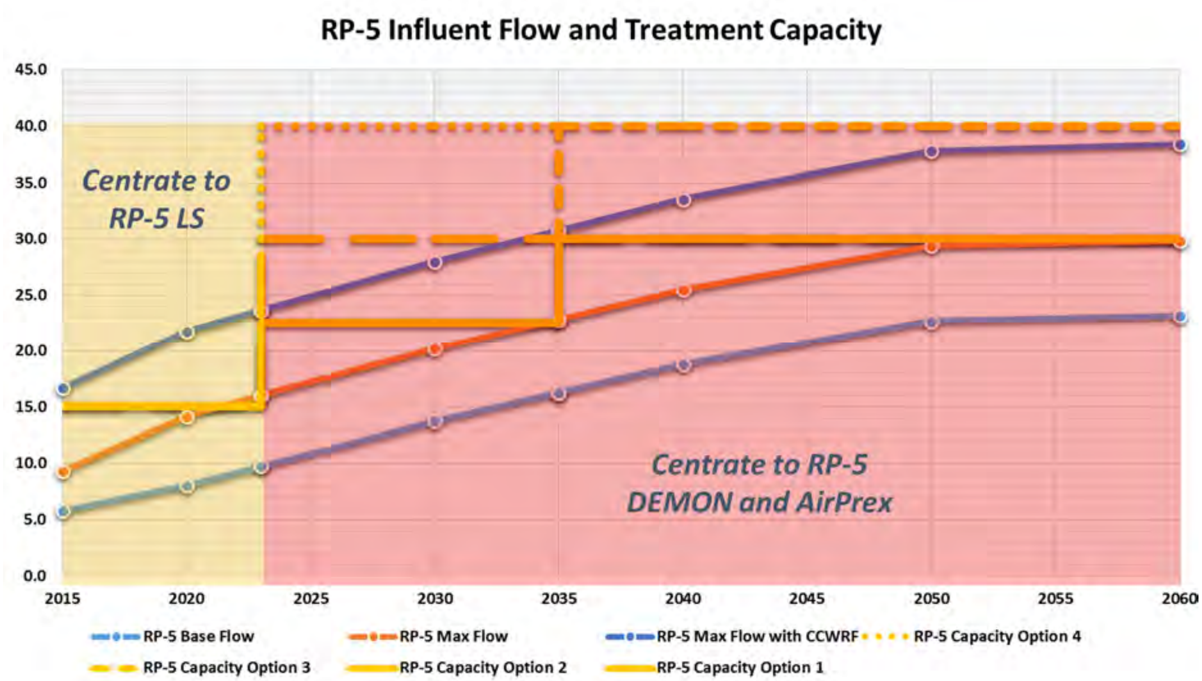


Figure 6-29: RP-5 Flow Forecast (mgd); RP-5 Alternative 5: Centrate to RP-5 DEMON and AirPrex

6.4.2 Screening Recommendations

Based on the alternatives presented above, the alternative combinations shown in Table 6-14 and Table 6-15 are recommended for the BCE analysis. These alternatives are summarized based on centrate time periods related to plant expansion at RP-1 and RP-5. The full BCE spreadsheets are presented in Exhibit I of this Volume.

Table 6-14: Final RP-1 Centrate Handling Alternatives

Alternative				Summary
Alternative	2016–22	2022–30	2030–45	
1	NRW	NRW	NRW	Alt 1 is based on discharge of centrate to NRW line for the duration of the project.
2	NRW	NRW	DEMON Sidestream	Alt 2 assumes continued use of the NRW line until the 2030 RP-1 plant expansion, when sidestream nitrogen removal can be constructed.
3	NRW	NRW	AirPrex	Alt 3 assumes continued use of the NRW line until the 2030 RP-1 plant expansion, when sidestream struvite removal can be constructed.
4	NRW	NRW	DEMON and AirPrex Sidestream	Alt 4 assumes continued use of the NRW line until the 2030 RP-1 plant expansion, when sidestream nitrogen and struvite removal can be constructed.
5	NRW	NRW	RP-1 Liquids	Alt 5 assumes continued use of the NRW line until the 2030 RP-1 plant expansion, when the centrate can be recycled back to a larger RP-1 secondary system designed to treat the recycle load.
6	NRW	RP-5 Liquids	RP-1 Liquids	Alt 6 assumes continued use of the NRW line until the 2022 RP-5 plant expansion, when the centrate will be sent to RP-5. After the 2030 RP-1 plant expansion, centrate can be recycled back to a larger RP-1 secondary system designed to treat the recycle load.
7	NRW	RP-5 Liquids	DEMON Sidestream	Alt 7 assumes continued use of the NRW line until the 2022 RP-5 plant expansion, when the centrate will be sent to RP-5. After the 2030 RP-1 plant expansion, sidestream nitrogen removal can be constructed to treat the centrate load.
8	NRW	RP-5 Liquids	AirPrex	Alt 8 assumes continued use of the NRW line until the 2022 RP-5 plant expansion, when the centrate will be sent to RP-5. After the 2030 RP-1 plant expansion, sidestream struvite removal can be constructed to treat the centrate load.
9	NRW	RP-5 Liquids	DEMON and AirPrex Sidestream	Alt 9 assumes continued use of the NRW line until the 2022 RP-5 plant expansion, when the centrate will be sent to RP-5. After the 2030 RP-1 plant expansion, sidestream nitrogen and struvite removal can be constructed to treat the centrate load.
10	NRW	NRW	RP-5 Liquids	Alt 10 assumes continued use of the NRW line until the 2030 RP-1 plant expansion, when the centrate will be sent to RP-5.
11	NRW	RP-5 Liquids	RP-1 Liquids	Alt 11 assumes continued use of the NRW line until the 2022 RP-5 plant expansion, when the centrate will be sent to RP-5. After the 2030 RP-1 plant expansion, centrate can be recycled back to a larger RP-1 secondary system designed to treat the recycle load.

Table 6-15: Final RP-5 Centrate Handling Alternatives

Alternative			Summary
Alternative	2016–22	2022–30	
1	RP-5 Liquids	IEBL	Alt 1 is based on discharge of centrate to IEBL line after the 2022 RP-5 plant expansion.
2	RP-5 Liquids	RP-5 Liquids	Alt 2 assumes centrate will be recycled to the RP-5 secondary system. The RP-5 plant expansion in 2022 will include a larger secondary system to process the recycle load.
3	RP-5 Liquids	DEMON Sidestream	Alt 3 assumes centrate will be recycled to the RP-5 secondary system. After the 2022 RP-5 plant expansion, sidestream nitrogen removal can be constructed to treat the centrate load.
4	RP-5 Liquids	AirPrex Sidestream	Alt 4 assumes centrate will be recycled to the RP-5 secondary system. After the 2022 RP-5 plant expansion, sidestream struvite removal can be constructed to treat the centrate load.
5	RP-5 Liquids	DEMON and AirPrex Sidestream	Alt 5 assumes centrate will be recycled to the RP-5 secondary system. After the 2022 RP-5 plant expansion, sidestream nitrogen and struvite removal can be constructed to treat the centrate load.

6.5 ALTERNATIVES COMPARISON

Capital, annual running, and repair and replacement (R&R) costs were estimated for the various centrate alternatives associated with RP-1 and RP-5.

6.5.1 Capital Costs

Capital cost estimates for the RP-1 and RP-5 alternatives are summarized in Table 6-16 and Table 6-17. Capital cost estimates are Class 4 estimates as defined by AACE International with an expected lower range accuracy of -15% to -30% and upper range accuracy of +20% to +50%.

Table 6-16: RP-1 Centrate Handling Alternatives Capital Costs ($1,000)

	Alt 1	Alt 2	Alt3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8	Alt 9	Alt 10	Alt 11
Description	NRW/ NRW/ NRW	NRW/ NRW/ DEMON	NRW/ NRW/ AirPrex	NRW/ NRW/ DEMON/ AirPrex	NRW/ NRW/ RP-1LS	NRW/ RP-5 LS/ RP-5 LS	NRW/ RP-5 LS/ DEMON	NRW/ RP-5 LS/ AirPrex	NRW/ RP-5 LS/ DEMON/ AirPrex	NRW/ NRW/ RP-5 LS	NRW/ RP-5 LS/ RP-1 LS
Centrate equalization			X		X	X		X		X	X
AirPrex			X	X				X	X		
DEMON		X		X			X		X		
RP-1 expansion for centrate		X	X	X	X		X	X	X		X
RP-5 expansion for centrate						X				X	
RP-5 methanol addition						X	X	X	X	X	X
Subtotal	$0	$8,150	$8,200	$10,700	$5,600	$4,250	$9,250	$9,250	$11,800	$6,400	$6,700
Construction costs: Contractor Overhead and profit: 15% Inflation: 8% Bond and Insurance: 4% Estimator's Contingency: 30% Allied costs: Design, Permitting and scope, Const. Management, Warranty, Engineering Contingency, and change order allowance: 20%											
Total	$0	$16,300	$16,400	$21,400	$11,200	$8,500	$18,500	$18,500	$23,600	$12,800	$13,400
Note: X's indicated features included in the Alternative											

Table 6-17: RP-5 Centrate Handling Alternatives Capital Costs ($1,000)

	Alt 1	Alt 2	Alt3	Alt 4	Alt 5
Description	IEBL/ IEBL	RP-5 LS/ RP-5 LS	RP-5 LS/ DEMON	RP-5 LS/ AirPrex	RP-5 LS/ DEMON/ AirPrex
Centrate equalization		X		X	
AirPrex				X	X
DEMON			X		X
RP-5 expansion for centrate		X	X	X	X
Subtotal	$0	$3,350	$5,300	$5,600	$7,600
Construction costs: Contractor's Overhead and profit: 15% Inflation: 8% Bond and Insurance: 4% Estimator's Contingency: 30% Allied costs: Design, Permitting and scope, Const. Management, Warranty, Engineering Contingency, and change order allowance: 20%					
Total	$0	$6,700	$10,600	$11,200	$15,200
Note: X's indicated features included in the Alternative					

Capital costs for the centrate handling alternatives include the following assumptions:

- Treatment performance for AirPrex and DEMON is based on data provided by the vendor and from other similar projects.
- Capital cost for the AirPrex system was based on a vendor quote for the equipment. Costs for the associated building and piping were estimated from costs developed for another similar project, with adjustment for local conditions. Capital cost for the DEMON system was estimated based on cost curves developed from other similar projects.
- The existing centrifuges at RP-1 and RP-2 operate 8 hours per day, 7 days per week. It was assumed that the dewatering systems at RP-1 and RP-5 will operate at the same schedule.
- A centrate storage tank and pump station were assumed to be required to provide flow and load equalization for all alternatives except for those where the centrate is sent to the brine pipeline. A storage tank is included in the DEMON system; therefore, a separate cost for the storage tank and pumps are not included for the alternatives involving DEMON.

6.5.2 Operating and Maintenance Costs

O&M costs were evaluated based on the unit costs shown in Table 6-18.

Table 6-18: Annual Running Unit Cost Assumptions

Item	Units	Cost	Notes
Polydyne Flowsperse	\$/gal	0.92	
Polymer (current use at site)	\$/gal	10.63	
Electrical power	\$/kWh	0.125	
Corrected FTE labor cost	\$/hr	96.33	
Current biosolids value	\$/ton	0	
Methanol (99% w/w solution)	\$/gal	2.55	Estimated from previous project in Idaho
kWh per lb of oxygen	kWh/lb O_2	0.3	Based on Sanitaire diffuser reference data
$MgCl_2$ (33% w/w solution)	\$/gal	0.6	Estimated from previous project in Idaho
Molar ratio	Mol Mg/Mol P	1.3	
$MgCL_2$ density	lb/gal	10.7586	
Solution concentration	wt/wt	0.33	
Molar wt. of P	g/mol	30.97	
Molar wt. of Mg	g/mol	24.305	
Ratio of $MgCl_2$ solution/1 lb P removed	lb/lb	10.97	

Other assumptions related to annual running costs include the following:

- The secondary systems at RP-1 and RP-5 are required to achieve an annual average total influent nitrogen (TIN) limit of 8 milligrams per liter (mg/L) based on the current National Pollutant Discharge Elimination System (NPDES) permit (could be applied on an agency-wide basis). Therefore, the need for supplemental carbon was estimated for each alternative.

- Methanol requirements were estimated based on BioWin simulations performed by Parsons for RP-5 with and without centrate from RP-1 routed to RP-5 under 2020 conditions. Based on those results, a ratio of 4.62 lb BOD/lb NO_3-N removed was calculated. This ratio was assumed to determine the need for methanol addition and, if methanol is needed, the methanol requirements.

- Capital cost for a methanol storage and feed system was extrapolated from cost estimates developed for another recent similar project, which includes a stainless-steel storage tank under a canopy roof structure, metering pumps, and associated piping and instrumentation.

- Aeration energy requirement is expressed as kilowatt-hours (kWh) per pound per day (lb/d) oxygen (O_2) required (as field oxygen requirement). Using site-specific information at RP-1 and RP-5 (in terms of elevation, existing basin depth), and assuming diffuser density (10 percent) and alpha factor (0.5), values of about 0.32 to 0.34 were calculated. A value of 0.30 was assumed for this analysis.

- Unit costs are based on data provided by Parsons, where available. These include unit labor costs ($96.33/hr, per BCE Manual provided by IEUA accounting for estimated hours of productive work), electricity cost ($0.125/kWh), and cost of Flowsperse for struvite control ($102,897/yr, at RP-1 only).

- Other unit costs, including those for $MgCl_2$ and methanol, are based on recent cost estimates developed for similar recent projects for other treatment plants (Meridian, Idaho).

- Centrate from RP-1 is currently discharged to the NRW pipeline. The rate structure for discharge to this pipeline was based on the current agreement between IEUA and Los Angeles County for fiscal year 2015–16.

- It was assumed that IEUA had paid the upfront purchase costs for a set number of CUs previously calculated. An annual lease cost is thus not required. The assigned CU was assumed to be 1,928 based on spreadsheets provided by Parsons. It was assumed that a surcharge would not be needed because of any exceedance of this assigned CU, even though it was estimated that the actual CU would exceed the assigned CU of 1,928 after 2037 based on the projected RP-1 centrate flow and loadings.

- The annual O&M and CIP charges are assumed to be based on the assigned CU only. Therefore, the annual O&M and CIP costs are the same each year (before escalation).

- Centrate generated at RP-2, which receives sludge from RP-5 and CCWRF, is currently sent to RP-5 along with other recycle flows. It was assumed that IEUA has already established an agreement to discharge into the IEBL, which reaches the jurisdiction of the

Santa Ana Watershed Project Authority. It was thus assumed that IEUA would not need to pay the initial capacity charge, application fees, and any permit renewal fees. The assigned CU was assumed to be 16, based on the projected 2045 centrate flow for RP-5.

- Energy costs do not include cost of pumping centrate. The centrate pumping volume is similar for each plant, RP-1 and RP-5. Therefore, it is assumed the centrate pumping costs are similar and will not impact the BCE assessment.

6.5.3 Repair and Replacement Costs

R&R costs were estimated for the sidestream nitrogen and struvite removal technologies. An annual R&R cost of 0.75 percent of the capital cost for DEMON was used and an annual R&R cost of 1.65 percent of the capital cost of AirPrex was used. The R&R rate for DEMON is lower than that of AirPrex because DEMON has more concrete structures as a proportion of cost; concrete structures have longer expected life than other equipment and electrical systems. No additional R&R costs were assumed for alternatives that included expansion of the secondary process to increase capacity for nitrogen removal. The minor additional impact of this recycle stream on the R&R requirements for the secondary process equipment was considered negligible. Additionally, centrate R&R costs associated with equalization and pumping was considered minor and approximately equivalent between alternatives.

6.5.4 Risks and Benefits

No risks or benefits were included in this BCE.

6.6 BUSINESS CASE EVALUATION

IEUA has adopted the BCE as the structured economic analysis used to make decisions based on life-cycle costs that include community, environmental, and risk considerations. The BCE is a step-by-step process that can be performed on any size project that requires a decision to be made from policy and capital planning to operations, maintenance, refurbishment, and information systems. This is a repeatable, defensible, and quantitative process that assists IEUA in making clear, actionable decisions on facilities rehabilitation or replacement.

The life-cycle benefit/cost analysis is based on the net present value (NPV) tool included in the IEUA template. NPV analysis is the most comprehensive method to make investment decisions by considering the total cost of a project over its entire life. Because costs or revenues may occur at different times during the duration of the project, time-value of money equations can be used to calculate the present value of all costs and revenues over the life cycle of a project.

Two parameters are particularly important in this analysis:

- *Escalation rate* is the result of many factors including the overall inflation in the currency, supply/demand of certain goods, technology changes, environmental effect, political conditions, and other miscellaneous effects. In most cases, the escalation rate is different from (although greatly influenced by) the currency inflation rate. Typically, the rate of escalation is above the general level of inflation. This means that the lifetime cost is weighted toward future years, and shorter-term capital expenses are favored. The escalation rate used in this evaluation is 3 percent.

- *Discount rate* is the rate of interest (or rate of return) that is expected from an alternative investment. Examples of alternative investments are interest from a bank, stock market appreciation, or expected profits from one's own business. Selection of high discount rates indicates the belief that a large profit can be made from an alternative investment. The discount rate used in this evaluation is 2 percent.

6.6.1 BCE Results

The life-cycle benefit/cost analysis based on the NPV tool was conducted for the alternatives under evaluation in this report. Results for BCEs for centrate handling at RP-1 and RP-5 are presented in Table 6-19 and Table 6-20.

Table 6-19: BCE Results for RP-1 Centrate Handling

Alternative	2016–22	2022–30	2030–45	Capital Cost ($1,000)	NPV ($1,000)	Difference from cheapest NPV ($1,000)
1	NRW	NRW	NRW	$0	($46,100)	($4,500)
2	NRW	NRW	DEMON Sidestream	$16,300	($46,100)	($10,100)
3	NRW	NRW	AirPrex	$16,300	($44,500)	($8,500)
4	NRW	NRW	DEMON and AirPrex Sidestream	$21,400	($54,400)	($18,400)
5	NRW	NRW	RP-1 Liquids	$11,200	($36,000)	
6	NRW	RP-5 Liquids	RP-1 Liquids	$8,500	($53,900)	($17,900)
7	NRW	RP-5 Liquids	DEMON Sidestream	$18,500	($48,500)	($12,500)
8	NRW	RP-5 Liquids	AirPrex	$18,500	($46,300)	($14,800)
9	NRW	RP-5 Liquids	DEMON and AirPrex Sidestream	$22,500	($56,200)	($10,200)
10	NRW	NRW	RP-5 Liquids	$12,800	$59,000	($20,300)
11	NRW	RP-5 Liquids	RP-1 Liquids	$13,400	$38,600	($23,100)

Table 6-20: BCE Results for RP-5 Centrate Handling

Alternative	2016–22	2022–30	Capital Cost ($1,000)	NPV ($1,000)	Difference from cheapest NPV ($1,000)
1	RP-5 Liquids	IEBL	$0	($13,300)	($4,100)
2	RP-5 Liquids	RP-5 Liquids	$6,700	($9,200)	
3	RP-5 Liquids	DEMON Sidestream	$10,600	($18,500)	($9,300)
4	RP-5 Liquids	AirPrex Sidestream	$11,200	($20,500)	($11,300)
5	RP-5 Liquids	DEMON and AirPrex Sidestream	$15,300	($29,800)	($20,700)

Based on the BCE for RP-1, Alternative 5, returning centrate flows to RP-1 liquids process after the 2030 plant expansion represented the lowest NPV alternative. Before 2030, it is most cost-effective to discharge the centrate flows to the NRW line. While RP-5 may have sufficient capacity to receive the centrate flows from RP-1 before 2030, it is anticipated that RP-5 will require methanol to process the additional nitrogen load. The additional chemical cost increases the NPV and does not represent the most cost-effective approach to centrate management.

The next-lowest NPV alternatives are Alternative 1 and Alternative 2. Alternative 1 assumes discharge of centrate to the NRW line for the duration of the project. This alternative does not require a capital cost, but there are substantial operating costs. In addition, some risks may be associated with this alternative. For example, the unit cost to discharge centrate may increase in the future, or the utilities receiving the NRW flows may increase restrictions on discharge quantity or quality.

RP-1 is a space-limited site, and if sufficient footprint is not available to expand the RP-1 secondary system to receive the centrate recycle, Alternatives 1 or 2 could be considered as the next-best approach to centrate management.

Results for BCE for centrate handling alternatives at RP-5 are presented in Table 6-20 above.

Based on the BCE for RP-5, Alternative 2, returning centrate flows to RP-5 liquids process after the 2030 plant expansion represented the lowest NPV alternative. While the site at RP-5 is limited, it is anticipated that a sufficient footprint at the site exists to accommodate increased secondary treatment capacity associated with centrate recycle.

6.6.2 Food Waste Impacts

IEUA is interested in accepting high-strength wastes for co-digestion to increase digester gas production. High-strength wastes include food processing wastes from industrial sources and food wastes currently disposed of as municipal solid wastes. It could also include fats, oil and grease (FOG). These are collectively referred to as food waste in this document. While addition of food wastes will improve digester performance and increase digester gas production, it will also increase the centrate flows and loads. The extent of the increase will depend on the quantities of food wastes (e.g., wet tons delivered per day) and the characteristics of the food wastes. For example, food wastes originating from fruits and grain products would have high organic content (as COD), while food wastes from meat processing would have high nitrogen content (as TKN).

The latter would have the largest impact on centrate treatment as the additional nitrogen load is not removed in the digesters and would either increase the requirements for any sidestream treatment process or increase the aeration and potential methanol requirements in the secondary system if the centrate is returned to the liquid stream processes for treatment. In the latter case, additional aeration basin volume may also be needed to accommodate the higher centrate loadings.

Based on data given in the Draft Co-Digestion/Digester Gas Utilization Feasibility Study prepared by Carollo Engineers (dated April 2016), up to 326 wet tons per day of food wastes may be sent to IEUA for co-digestion. Assuming that this quantity of food wastes is sent to RP-5 and typical characteristics for food waste that is not excessively high in nitrogen content, the centrate flow at RP-5 could increase by about 10 to 20 percent, while the ammonia loading could increase by 20 to 30 percent, when compared to the estimated design centrate flows and ammonia loadings without food waste. The percent increases will be less if IEUA receives less than 100 percent of the available food wastes. Based on these estimates, the capital cost of the DEMON system for sidestream treatment at RP-5 is estimated to increase from $11.0 million to approximately $14.7 million. For alternatives considering recycle of centrate to the secondary system, the capital cost of the liquids system expansion would also increase to account for recycle ammonia load. The cost of the secondary system expansion would vary depending on the design solids loading and food waste quantity and quality for co-digestion. It is expected that the additional cost of food waste to the secondary system would be approximately $2.5M.

A sensitivity analysis of the RP-1 and RP-5 alternatives indicated that when the recycle of centrate to the secondary process of each plant required the addition of an external carbon source such as methanol, the high operating costs associated with methanol addition resulted in alternatives that used sidestream ammonia removal through processes such as DEMON as the lowest net present value alternative. For this evaluation, it was assumed that the plant influent characteristics were sufficient that recycle of centrate to the secondary process did not require the additional of methanol. The addition of food waste at RP-5 will increase the nitrogen load in the centrate and would likely result in centrate discharge to the IEBL (Alternative 1) as the lowest net present value alternative. As previously mentioned, there are risks associated with relying upon this brine line for dedicated centrate disposal. If this option were not available, reliable, or practical for long term operation, the sidestream nitrogen removal alternative (Alternative 3) would represent the lowest net present value approach to centrate handling.

6.6.3 Phasing Considerations for Food Waste Addition

Currently is it assumed that RP-1 secondary capacity will expand in 2030 to 40 mgd. Based on the BCE findings presented in Table 6-19 above, expansion of RP-1 to include recycle of centrate to the secondary process represents the lowest net present value alternative. Prior to 2030, the centrate could be transferred to the NRW line or RP-5.

Several expansion opportunities at RP-5 exist to increase capacity at the plant over several increments. Workshop #1 review comments related to centrate handling at RP-5 included a request to consider phasing opportunities at RP-5 as it relates to centrate handling. The BCE alternatives presented above assume phasing of RP-5 in 2023 to 40 mgd secondary system capacity. Other opportunities to be considered include:

- Option 1: Install sidestream treatment in 2023 for ammonia removal

Regardless of the secondary system expansion phasing, install centrate sidestream treatment for ammonia removal in 2023, sized to treat future 2045 centrate loads and anticipated loads associated with food waste co-digestion.

- Option 2: Expand the secondary system to 22.5 mgd in 2023 and install sidestream ammonia removal in 2035

  Expand secondary capacity to 22.5 mgd in 2023 and provide additional capacity in the secondary system to treat centrate recycle. While an additional carbon source such as methanol is not anticipated to be required from solids centrate alone, the inclusion of food waste co-digestion will increase the ammonia concentration in the centrate and will require provisions for methanol or another carbon source.

  Expand the secondary capacity to 30 or 40 mgd in 2035 and provide additional centrate treatment capacity through the installation of sidestream ammonia removal, such as DEMON. The sidestream treatment system should be sized for 2045 solids loads and to accommodate centrate ammonia removal, including increased ammonia concentrations related to food waste co-digestion.

- Option 3: Expand the secondary system to 30 mgd in 2023 and install sidestream ammonia removal in 2035

  Expand secondary capacity to 30 mgd in 2023 and provide additional capacity in the secondary system to treat recycle centrate. While an additional carbon source such as methanol is not anticipated to be required, the inclusion of food waste will likely increase the ammonia concentration in the centrate and require provisions for methanol or another carbon source.

  Expand the secondary capacity to 40 mgd in 2035 and provide additional centrate treatment capacity through the installation of sidestream ammonia removal, such as DEMON. The sidestream treatment system should be sized to accommodate centrate ammonia removal, including increased ammonia concentrations related to food waste co-digestion.

- Option 4: Expand the secondary capacity to 40 mgd in 2023

  Expand secondary capacity to 40 mgd in 2023 and provide additional capacity in the secondary system to treat recycle centrate. While an additional carbon source such as methanol is not anticipated to be required, the inclusion of food waste will likely increase the ammonia concentration in the centrate and require provisions for methanol to be added if needed.

Based on these alternatives, Table 6-21 outlines the anticipated schedule and anticipated capital costs.

Table 6-21: Phasing Considerations for RP-5, Including Food Waste

	2023 Expansion		2030 Expansion	
Phasing Option	Description	Anticipated Capital Cost	Description	Anticipated Capital Cost
Option 1	Install sidestream treatment ammonia removal for 2045 loads.	$15.1M[a]	-	-
Option 2	Expand secondary capacity for 22.5 mgd, including recycle of centrate and capability for methanol addition.	$11.2M[b]	Expand secondary capacity for 30 or 40 mgd. Install sidestream treatment ammonia removal for 2045 loads.	$13.7M[e]
Option 3	Expand secondary capacity for 30 mgd, including recycle of centrate and capability for methanol addition.	$12.6M[c]	Expand secondary capacity for 40 mgd. Install sidestream treatment ammonia removal for 2045 loads.	$13.7M[e]
Option 4	Expand secondary capacity for 40 mgd, including recycle of centrate and capability for methanol addition.	$14.3M[d]	Install sidestream treatment ammonia removal for 2045 loads	$13.7M[e]

[a] Cost assumes $13.7M DEMON side stream treatment with centrate from food waste co-digestion and an additional $1.4M expansion of the secondary system to process effluent nitrogen from DEMON.
[b] Cost assumes $4.1M expansion of the secondary system for centrate recycle, an additional $2.3M secondary expansion for nitrogen recycle associated with food waste, $1.7M for centrate equalization, and $3.1M for a methanol addition facility.
[c] Cost assumes $5.5M expansion of the secondary system for centrate recycle, an additional $2.3M secondary expansion for nitrogen recycle associated with food waste, $1.7M for centrate equalization, and $3.1M for a methanol addition facility.
[d] Cost assumes $7.3M expansion of the secondary system for centrate recycle, an additional $2.3M secondary expansion for nitrogen recycle associated with food waste, $1.7M for centrate equalization, and $3.1M for a methanol addition facility.
[e] Cost assumes $13.7M DEMON side stream treatment with centrate from food waste co-digestion. No additional costs is included for expansion of the secondary system to process effluent nitrogen from DEMON as it is assumed the capacity for centrate ammonia treatment was installed during a previous expansion (in 2023 or 2030).

6.7 CONCLUSIONS AND RECOMMENDATIONS

This section presents conclusions and recommendations resulting from the analysis.

6.7.1 Conclusions

Results for the BCE suggest the following:

- For RP-1: Alternative 5, returning centrate flows to RP-1 liquids process after the 2030 plant expansion, represented the lowest NPV alternative. The next-lowest NPV alternatives are Alternative 1 and Alternative 2. Alternative 1 assumes discharge of centrate to the NRW line for the duration of the project. Alternative 2 assumes centrate is treated with DEMON. RP-1 is a footprint-limited site, and if insufficient footprint is available to expand the RP-1 secondary system to receive the centrate recycle, Alternatives 1 or 2 could be considered as the next-best approach to centrate management.

- For RP-5: Based on the BCE for RP-5, Alternative 2, returning centrate flows to RP-5 liquids process after the 2030 plant expansion represented the lowest NPV alternative.
- Based on current experiences at RP-1 and RP-5 and projections that future organic loads will increase, methanol is not anticipated at RP-1 and RP-5 (except when treating centrate from RP-1 at RP-5). If loads do not increase as projected, methanol may be required in the future, and operating costs associated with methanol will change the economics of centrate treatment in the liquids stream. In such cases, discharge of centrate to the brine lines will be the most cost-effective approach to centrate handling.
- Risks are associated with long-term planned use of the brine lines. If a cost is applied to alternatives associated with discharge of centrate to the brine lines, recycling of centrate to the liquids stream or sidestream nitrogen removal through DEMON (or another annamox technology) will become the next most economically attractive alternatives.
- This BCE was conducted during early stages of the project, and limited mass balance information was available. For this evaluation, the estimation of centrate flows and characteristics uses the best information available to provide an assessment of the alternatives. It is assumed the this approach will be sufficient for recommending centrate handling approaches, and selection of these technologies will allow continued development and refinement of future project mass balance efforts.
- The addition of food waste to the digestion process at RP-5 will have the impact of increasing the centrate flow and ammonia load. While the exact impact will depend on the food waste quantity and quality, it is anticipated that food waste will increase the ammonia recycle nitrogen load. If recycled to the secondary system, the need for an additional carbon source such as methanol is anticipated. Based on sensitivity analysis of BCE alternatives for RP-5, the additional of methanol will result in the Alternatives 1 (centrate discharge to IEBL) and 3 (centrate sidestream treatment with DEMON) as the lowest net present value alternatives. As previously mentioned, there are risks associated with relying upon this brine line for dedicated centrate disposal. If this option were not available, reliable, or practical for long term operation, the sidestream nitrogen removal alternative (Alternative 3) would represent the lowest net present value approach to centrate handling.
- Phasing has the potential to offset capital costs related to handling of centrate at RP-5. A summary of these anticipated costs, including the impact of food waste, are presented in Table 6-21.

6.7.2 Recommendations

Based on the analysis provided, the following preliminary recommendations are provided:

- At RP-1, expanding the secondary system in 2030 to accommodate centrate recycle is the lowest net present value alternative and is recommended. Prior to 2030, the centrate can be discharged to the NRW line or transferred to RP-5. If footprint or other factors limit the ability to expand the secondary capacity to accommodate centrate recycle, centrate treatment can be managed with sidestream ammonia removal or transfer of centrate to RP-5.

- For this evaluation, it was assumed that the RP-1 influent characteristics were sufficient that recycle of centrate to the secondary process did not require the additional of methanol. The requirements for methanol or other carbon sources should be evaluated in more detail in later stages of the project.

- It is anticipated that the capital costs associated with operation of food waste co-digestion and recycle of centrate to the secondary process at RP-5 will range from $12-16M, depending on the secondary capacity to be installed in 2023. Further, installation of sidestream nitrogen removal or additional secondary capacity will be required to process centrate after 2030. Installation of sidestream nitrogen removal in 2023 is expected to cost approximately $16.2M. For budgetary purposes, it is recommended that centrate handling at RP-5 assume a sidestream nitrogen removal process at $16.2M. The impacts of food waste can then be further evaluated during scheduled project efforts and PDR development to determine if other lower initial cost options are appropriate.

- It is recommended that if sidestream nitrogen removal is the preferred alternative, a pilot trial of the technology be conducted to allow operations staff to gain a level of familiarity with the new technology.

Inland Empire Utilities Agency
A MUNICIPAL WATER DISTRICT

Evaluation of RP-5 Solids Treatment Alternative Technologies

Predesign Report
Volume III, Chapter 7

February 28, 2017

submitted by

PARSONS

in association with

Brown AND Caldwell

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

THIS PAGE INTENTIONALLY LEFT BLANK.

CHAPTER 7: EVALUATION OF RP-5 SOLIDS TREATMENT ALTERNATIVE TECHNOLOGIES

7.1 INTRODUCTION

7.1.1 Background

The Wastewater Facilities Master Plan (WFMP) evaluated the Regional Water Recycling Plant #5's (RP-5's) existing wastewater treatment capacity and concluded it would be exceeded by the year 2025. In addition, the solids loading from the Carbon Canyon Water Recycling Facility (CCWRF) and RP-5 already exceeds the digester capacity at RP-2, where these solids streams are currently treated. Due to the United States Army Corps of Engineers (USACE) project to raise the Prado Dam Spillway, the RP-2 solids treatment facility will need to be decommissioned and a new RP-5 solids treatment facility constructed with a design capacity to treat the projected flows.

7.1.2 Understanding and Approach

Based on the background of the project, the new solids treatment facility at RP-5 will consist of Thickening, Digestion and Dewatering. This chapter describes the approaches used to develop solids production projections and characteristics used for sizing the treatment processes and presents business case evaluations (BCEs) for each of the main solids processes.

The purpose of the BCEs is to provide sufficient comparative information on costs, benefits, and risks of the alternatives to provide a sound basis for technology selection. Sizing, loading, process configurations, layouts, and costs are based on project parameters agreed upon by the project team and Agency staff at the time of commencing the BCEs for the 2045 design year.

These evaluations of technologies (BCEs) and other important project conditions were conducted in parallel and results can impact the final configurations. Therefore, refinement of the final selected alternative and costs will be conducted after the BCEs and technology selection described in this chapter are completed. This refinement will be reflected in the Approved Project Requirements document and integrate into the final design decisions made by the Agency on project phasing, final load decisions related to food waste (FW) and fats, oils, and grease (FOG) treatment, staff layout and configuration preferences, and other decisions subsequent to the BCE evaluations.

Based on the background of the project, the new solids treatment facility at RP-5 will be sized to process future solids productions at RP-5 and CCWRF. In addition, FOG and FW are assumed to be treated at RP-5. All BCE analysis are provided in Exhibit I of this Volume. Note that subsequent decisions on handling FOG and FW will be discussed in the Approved Project Requirements section of the Pre-Design Report.

7.2 SOLIDS CHARACTERISTICS AND PRODUCTION

This introductory section presents project background as well as and understanding and approach for solids mass balance development.

Solids flows and loads were estimated based on future influent flows to RP-5 and CCWRF and solids production rates at each plant.

7.2.1 Plant Influent Flow

Projected plant influent flows at various Inland Empire Utilities Agency (IEUA) facilities through 2060 under various flow diversion scenarios were provided by the IEUA (Appendix 7-A). As instructed by the Agency, the following scenarios were selected for RP-5 Solids Treatment Alternatives Evaluation.

- RP-5: Flow to RP-5 includes gravity flow and maximum diversion flow.
- CCWRF: Flow to CCWRF includes gravity flow only.

The projected plant influent flows at RP-5 and CCWRF are summarized in Table 7.2-1.

Table 7.2-1: Plant Influent Flow at Maximum Month Condition, mgd

Year	RP-5	CCWRF
2016	9.3	7.4
2020	14.2	7.6
2025	16.0	7.6
2030	20.2	7.8
2035	22.8	7.9
2040	25.5	8.1
2045	27.6	8.2
2050	29.5	8.3
2060	30.0	8.5

7.2.2 Solids Production Rates and Peaking Factors

Sludge production values were estimated on a per million gallons' basis using the influent design pollutant concentrations decided upon on March 11, 2016. These influent design concentrations were chosen after analysis of 5 years of the existing plant data with consensus among the design team and IEUA staff. These design concentrations are provided in Appendix 7- B of this document. The design concentrations chosen were based on maximum month values. If the 90th percentile concentration was greater than the max month value, then the 90th percentile value was used. Sludge production rates are summarized in Table 7.2-2.

Table 7.2-2: Sludge Production Rates at Max Month Condition, lb/MG

Parameter	RP-5	CCWRF
Max Month Primary Sludge	2,335	2,919
Max Month WAS	1,297	1,633
Max Month Total Sludge	3,632	4,552

[a] FOG and FW are not included in these sludge quantity estimates

Sludge productions fluctuates throughout the year as the plant influent flow and characteristics change. The solids handling facilities and associated equipment must be sized properly to be able to handle solids productions at peak events. Therefore, several peaking factors are needed, including max day, max week, max 2-week, and max month to design the solids system.

However, there is not enough data available to determine all peaking factors to this level of precision. The peaking factors were determined by reviewing the available influent data as well as using the design team's engineering judgement, knowledge, and experience. Influent data was used to develop peaking factors because there was not enough available data on primary sludge and waste activated sludge (WAS) flow and solids percentage.

The peaking factors were developed for combined sludge as well as separate primary sludge and WAS. Peaking factors for combined sludge will be used to size equipment after the two sludge streams are combined, such as combined thickening, digestion, and dewatering. Peaking factors for separate primary sludge and WAS productions will be used to size equipment for separate sludge thickening alternatives. The peaking factors for separate sludge streams are slightly higher than those of combined sludge as peak sludge productions of primary sludge and WAS typically do not occur simultaneously. The peaking factors are summarized in Table 7.2-3.

Table 7.2-3: Sludge Production Peaking Factors[a]

Parameter	Combined Sludge	Separate Sludge[b,c,d]
Max Month / Annual Average	1.40[a]	1.60
Max 2-Week / Max Month	1.68[b]	1.75
Max Week / Max Month	1.75[b]	1.90
Max Day / Max Month	1.82[a]	2.10

[a] Based on a review of existing plant data.

[b] Not enough existing data to determine this precise peaking factor – value based on the judgment and experience of the design team and interpolated from influent data (See Vol. II Chapter 7)

[c] Peaking factors for separate sludge streams are higher than those of combined sludge because peak primary sludge and WAS productions typically do not occur simultaneously

[d] Peaking factors for PS and WAS are assumed to be the same

7.2.3 Projected Solids Flows and Loads

Solids productions at maximum month (MM) conditions were developed by multiplying plant influent flow shown in Table 7.2-1 and the unit solids production rates shown in Table 7.2-2. Solids productions at other conditions were developed based on the MM conditions solids productions and the peaking factors shown in Table 7.2-3.

Major assumptions used to project future solids flows and loads include:

- Plant influent flows projections and unit solids production rates (pounds [lbs] of solids produced per million gallon of plant influent) estimates were based on population growth projection taking into account future water conservation.
- Unit solids production rates and solids production peaking factors remain the same throughout the evaluation period.
- Peaking factors for primary sludge and WAS are the same. The peaking factors for primary sludge and WAS might not be the same in reality. However, they are assumed to be the same due to not enough existing data to determine peaking factors for separate primary sludge and WAS. Such assumption has little impact on combined sludge projections. The design team believes that the higher peaking factors assumed for separate primary sludge and WAS projections are conservative for sizing the solids handling facilities that treat separate sludge streams.

- Primary sludge will be wasted from the primary clarifiers. WAS will be wasted from the return activated sludge (RAS) line. Total solids content of the primary sludge and WAS is 0.8%based on the IEUA's preference for sludge pumping.
- Volatile solids of primary sludge are 85%of total solids. This is based on the assumption that the volatile solids of primary sludge are the same as the VSS portion of plant influent.
- Volatile solids of WAS is 88.4% of total solids. This is based on the calculations and assumptions used for solids production estimation in Appendix 7- B.

Projected solids flow and loads at 2060 are summarized in Table 7.2-4. Combined sludge flows and loads were used to size process equipment that treats combined sludge, such as combined thickening, digestion, and dewatering. Separate primary and WAS flows and loads were used to size process equipment that treat the two sludge streams separately, such as separate thickening and associated pumps and piping.

Table 7.2-4: Projected Sludge Productions in 2060

Parameter	Units	Average Annual	Max Month	Max 2-Week	Max Week	Max Day
Combined Sludge						
Sludge Flow	gpd	1,581,000	2,213,000	2,656,000	2,766,000	2,877,000
Total Solids	%	0.8				
Total Solids	ppd	105,000	148,000	177,000	185,000	192,000
Volatile Solids	% of TS	86				
Volatile Solids	ppd	91,000	127,000	153,000	159,000	166,000
Separate Sludge – Primary Sludge						
Sludge Flow	gpd	1,016,000	1,660,000	1,815,000	1,971,000	2,178,000
Total Solids	%	0.8				
Total Solids	ppd	68,000	111,000	121,000	131,000	145,000
Volatile Solids	% of TS	85				
Volatile Solids	ppd	58,000	94,000	103,000	112,000	124,000
Separate Sludge – WAS						
Sludge Flow	gpd	565,000	924,000	1,010,000	1,097,000	1,212,000
Total Solids	%	0.80				
Total Solids	ppd	38,000	62,000	67,000	73,000	81,000
Volatile Solids	% of TS	88				
Volatile Solids	ppd	565,000	924,000	1,010,000	1,097,000	1,212,000

7.2.4 High Strength Waste for Co-digestion

The IEUA is interested in accepting high-strength wastes (HSWs) for co-digestion to increase digester gas production. High-strength wastes include FOG and FWs from commercial sources.

The design team conducted an extensive literature review to identify the quantities of FOG and food waste available for co-digestion on local market and best practices in the industry to co-digest HSW at municipal wastewater treatment plants. Details of identifying quantities and qualities of HSWs are discussed in in Chapter 8 of this Volume.

In summary, the following criteria were used for the solids handling facility BCE evaluation:

- Total HSW (FOG and food waste) for co-digestion is limited to 30% of the load to the digesters on a volatile solids basis at annual average condition. The 30% limit is deemed as the best practice in the industry to maximize digester gas production without impairing normal digester operation and stability.
- Quantities of HSW at other conditions (max month, peak week, etc.) are the same as those at annual average condition for a given design year. This ensures the HSW load is always below the 30% limit and minimizes the risk of over loading the digesters.
- Dewatering equipment were sized assuming that all HSW for co-digestion is food waste. This is conservative for dewatering equipment sizing as food waste has lower volatile solids content and lower volatile solids reduction during digestion, resulting in more digested material for dewatering.

Quantities and characteristics of FOG and food waste used for the BCE evaluations are summarized in Table 7.2-5.

Table 7.2-5: Projected FOG and Food Waste Quantities for Co-Digestion in 2060

Parameter	Units	Value
FOG		
Flow	gpd	21,000
Total Solids	%	6
Total Solids	ppd	11,000
Volatile Solids	% of TS	90
Volatile Solids	ppd	10,000
Food Waste		
Flow	gpd	30,000
Total Solids	%	14
Total Solids	ppd	35,000
Volatile Solids	% of TS	85
Volatile Solids	ppd	29,000
Food Waste (For Dewatering Equipment Sizing)		
Sludge Flow	gpd	39,000
Total Solids	%	14
Total Solids	ppd	46,000
Volatile Solids	% of TS	85
Volatile Solids	ppd	39,000

7.3 EVALUATION OF RP-5 SOLIDS THICKENING ALTERNATIVES

7.3.1 Introduction

This introductory section presents a project background, understanding and approach, and a list of solids thickening alternatives evaluated using a BCE. The BCE is a life-cycle benefit/cost analysis based on the net present value (NPV). NPV analysis is the most comprehensive method to make investment decisions by considering the total cost of a project over its entire life. Because costs or revenues may occur at different times during the duration of the project, time-value of money equations can be used to calculate the present value of all costs and revenues over the life cycle of a project.

The purpose of the BCE is to provide sufficient comparative information on costs, benefits, and risks of the alternatives to provide a sound basis for technology selection. Sizing, loading, process configurations, layouts, and costs are based on project parameters agreed upon by the project team and Agency staff at the time of commencing the BCEs. Since evaluations of technologies and other important project conditions were conducted in parallel and results can impact the final configurations, refinement of the final selected alternative and costs will be conducted after the BCE and technology selection described in this chapter. This refinement will be reflected in the Approved Project Requirements document and integrated into the design final decisions made by the Agency on project phasing, final load decisions related to food waste and FOG treatment, staff layout and configuration preferences, and other decisions subsequent to the BCE.

The following are the alternatives considered for thickening sludge at the new facility:

- Gravity Thickening
- Dissolved Air Flotation Thickener (DAFT)
- Centrifuge
- Membrane Thickening
- Rotary Drum Thickener (RDT)
- Gravity Belt Thickener (GBT)

7.3.2 Solids Feed Characteristics and Production

7.3.2.1 Introduction

Thickening is used to increase the solids content and reduce the volume of sludge by removing a portion of water from the sludge feed. This reduction in volume increases the solids retention time (SRT) in a subsequent digester relative to digestion without thickening. Thickening, reduces the overall costs of sludge processing and handling.

Solids thickening is achieved through physical separation of solids particles from the liquid. The mechanism used for separation is often one of the following: centrifugal force, filtration, screening, sedimentation, or flotation. All of these are represented by the technologies being evaluated. The effectiveness of the separation mechanism depends upon hydraulic flow rate, solids loading rate, and the quantity of chemicals used for increasing particle size (e.g., polymer flocculation).

The new solids treatment facility at RP-5 will received sludge generated from the primary clarifiers (Primary Sludge) and from the secondary treatment process (WAS). The two streams can be thickened separately or blended into a homogenous mix to be co-thickened. Both, separate thickening and co-thickening, have advantages and disadvantages and will be evaluated as part of this BCE.

7.3.2.2 Separate Thickening

In the case of separate thickening, Primary Sludge and WAS are thickened independently. Prior to entering the thickening units, flow from each stream is equalized to shave off peaks and prevent solids washout. After the thickening process, the separate streams are conveyed to the sludge storage tank in the Digester Facility to be blended prior to feeding into the digesters. Figure 7.3-1 shows the main components assumed for separate thickening scenarios.

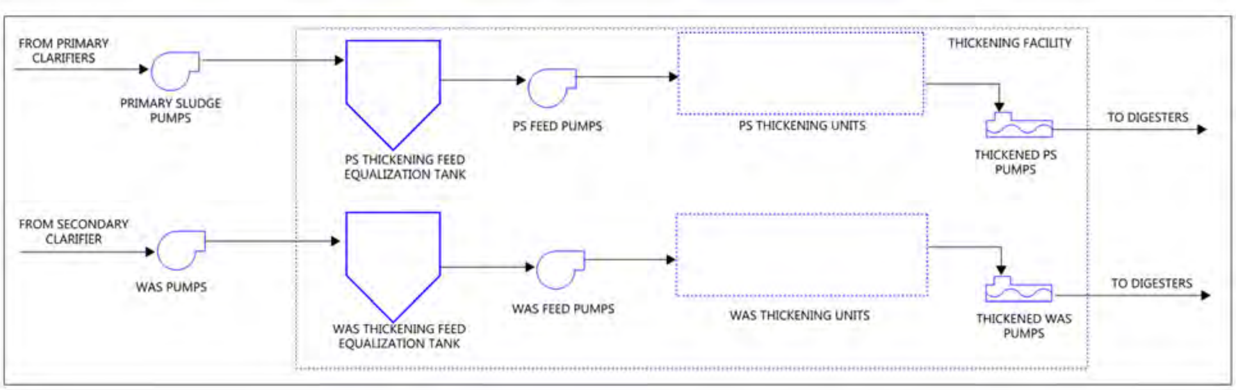


Figure 7.3-1: Process Flow Diagram for Separate Thickening

An advantage of thickening streams separately is that thickening technologies benefit from having a consistent feed. By having a consistent feed, the polymer dosage for each can be fine-tuned and would not require much adjustment to produce a consistent thickened sludge concentration.

7.3.2.3 Co-thickening

In the case of co-thickening, Primary Sludge and WAS are blended in a sludge blending tank prior to entering the thickening units. After thickening, the thickened sludge is conveyed to the Digestion Facility. Figure 7.3-2 shows the main components assumed for co-thickening scenarios.

Co-thickening helps reduces odors during the thickening process, because of the additions of WAS to Primary Sludge, which helps absorb some of the volatile fatty acids. In addition, co-thickening typically requires one less thickening unit than separate thickening because Primary Sludge and WAS peak production does not occur at the same time and, consequently, can be accommodated by the same unit.

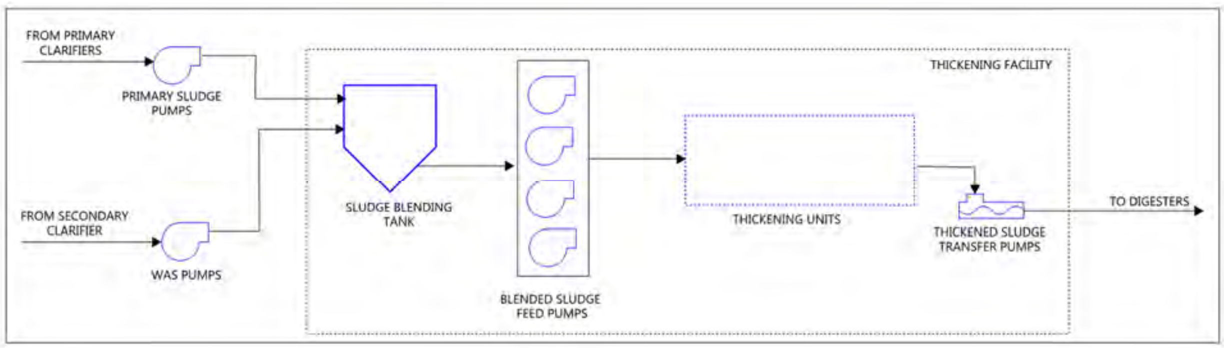


Figure 7.3-2: Process Flow Diagram for Co-thickening

7.3.2.4 Solids Feed Characteristics

Projected maximum day and average annual flows and loads are summarized in Table 7.3-1. The development and assumptions to produce flow and loads projections are presented in Section 7.2. Because the majority of the thickening technologies evaluated are hydraulically limited, with the exception of the DAFT, the thickening facility will be sized to accommodate maximum day flows and loads.

Table 7.3-1: Thickening Process Feed Solids Projections

Parameter	Units	Design Year					
		2025		2045		2060	
		Average Annual	Max Day	Average Annual	Max Day	Average Annual	Max Day
Primary Sludge							
Solids loading	lb/d	42,500	89,300	63,100	132,600	67,800	145,300
Solids flow	gpd	637,500	1,338,700	946,200	1,987,000	1,015,600	2,178,300
Solids concentration	%TS	0.8		0.8		0.8	
WAS							
Solids loading	lb/d	23,700	49,700	35,100	73,800	37,700	80,900
Solids flow	gpd	355,000	745,600	526,600	1,105,800	565,200	1,212,200
Solids concentration	%TS	0.8		0.8		0.8	
Combined Sludge [a]							
Solids loading	lb/d	66,200	120,500	98,300	178,800	105,500	191,900
Solids flow	gpd	992,500	1,806,300	1,472,800	2,680,500	1,580,700	2,876,900
Solids concentration	%TS	0.8		0.8		0.8	

a. Because peak production of Primary Sludge and WAS Sludge occurs at different times, two sets of peaking factors assumed to develop sludge productions at peak conditions for combined sludge.

7.3.3 Solids Thickening Technology Descriptions

7.3.3.1 Gravity Thickener

A gravity thickener, an example of which is shown on in the Figure 7.3-3 below, operates much like conventional primary or secondary clarifiers, with solids settling to the bottom of a tank via gravity. The process performs best when it receives sludge continuously to promote a stable sludge blanket. This reduces the occurrence of rising sludge by minimizing hydraulic residence time. The sludge blanket provides some means for additional sludge storage.

Figure 7.3-3: Gravity Thickener

7.3.3.2 Dissolved Air Flotation Thickener (DAFT)

A DAFT uses tiny air bubbles to separate solids from the liquid stream. A recycle stream from the DAFT subnatant is pressurized and mixed with the feed sludge just before entering the DAFT. When the recycle stream depressurizes upon entering the DAFT tank, dissolved air is released as fine bubbles attach to the sludge solids and carry them to the upper water surface, where they concentrate and are removed. Heavy solids settle out and are removed as DAFT underflow.

Figure 7.3-4: Dissolved Air Flotation Thickener

(Photo courtesy of Ovivo)

7.3.3.3 Centrifuge Thickener

Centrifuge thickeners involve separation of sludge particles and water under the influence of centrifugal forces induced through the force from high-speed rotation of a cylindrical bowl. A solid-bowl centrifuge operates as a continuous feed unit which removes solids using a scroll conveyor and discharges liquid over an end weir. The bowl is a conical-shape, which helps lift solids out of the liquid, allowing them to dry on an inclined surface before being discharged.

Figure 7.3-5: Centrifuge Thickener

(Photo courtesy of Alfa-Laval)

7.3.3.4 Membrane Thickener

Membrane thickening is a relatively new application of existing membrane bioreactor technology. Compared to a membrane bioreactor, a membrane thickening process operates with a higher solids concentration in the reactor, but at a much lower flux rate (about one third). A lower flux rate prevents the higher solids concentration from quickly fouling the membranes. The membrane thickener concentrates sludge by drawing excess water through the membranes, leaving behind the sludge solids.

Figure 7.3-6: Membrane Thickener

(Photo Courtesy of Ovivo)

7.3.3.5 Rotary Drum Thickener (RDT)

In RDTs, sludge is conditioned with polymer before being introduced into a slow rotating screen. Free water drains through the screen openings and collects in a trough underdrain. Thickened sludge is conveyed through the rotating drum and out the discharge end via a continuous internal screw or angled flights. The drum is sometimes inclined to aid in dewatering. An example of a single-drum style RDT is shown in the figure below.

Figure 7.3-7: Rotary Drum Thickener

(Photo courtesy of Parkson)

7.3.3.6 Gravity Belt Thickener (GBT)

GBTs were originally developed based on the gravity section of a belt filter press, where the majority of dewatering occurs. This process uses gravity to drain water from the polymer-conditioned sludge as it travels over a filter belt that is under tension. The water is collected beneath the belt as the concentrated sludge is carried above the belt to the discharge end of the thickener.

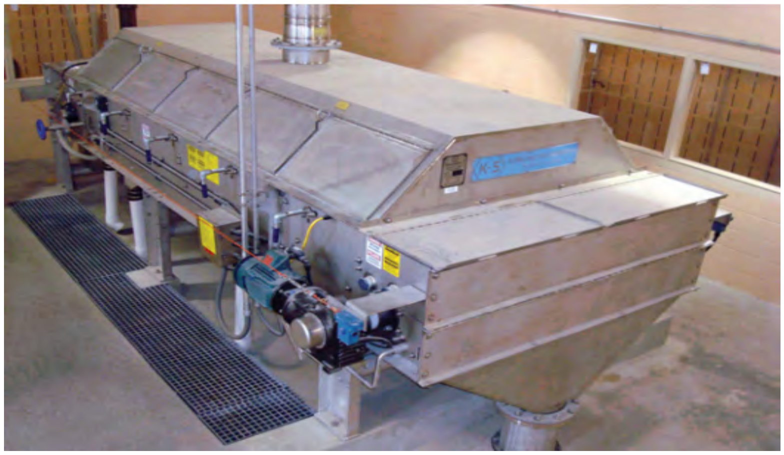


Figure 7.3-8: Gravity Belt Thickener

(Photo courtesy of Komline-Sanderson)

7.3.4 Thickening Alternatives Screening

7.3.4.1 Comparison of Thickening Technologies

Subjective considerations for the thickening technology alternatives were presented for consideration as part of the selection process and are provided below. The main factors considered in the pros and cons comparison are capital cost, anticipated performance, equipment footprint, potential for odors, and energy and water consumption. Table 7.3-2 lists the pros and cons for each technology.

Table 7.3-2: Pros and Cons for Thickening Technologies

Gravity Thickener	DAFT	Centrifuge
Pros	**Pros**	**Pros**
Effective at accommodating hydraulic peaks without decrease performance.	Effective at accommodating hydraulic peaks without decrease performance.	Solids concentrations of 4% – 8%
Allows for grit removal that can damage downstream equipment.	Allows for grit removal that can damage downstream equipment.	95% – 99% solids capture
Plant staff is familiar with equipment	Plant staff is familiar with equipment	Odors are contained/ Reduced odor potential
Minimal power requirements		Low wash water
Easy operation/does not require monitoring		Relatively small footprint -- smaller building requirement

Gravity Thickener	DAFT	Centrifuge
Cons	**Cons**	**Cons**
High capital cost	Highest capital cost	High capital cost
Not well suited for WAS thickening	Not well suited for Primary Sludge thickening	Energy intensive
Odor nuisance/ Requires high volume of Odor Control	Odor nuisance/ Requires high volume of Odor Control	Complex to operate – high-rotational speed equipment, means highest O&M labor cost of the alternatives
Large footprint	Energy intensive	High noise potential
	Large footprint	
	Many pieces of equipment requiring maintenance	

Membrane Thickener	RDT	GBT
Pros	**Pros**	**Pros**
Modular design requires less space than tank alternatives.	Lowest capital cost	Low capital cost
Nearly 100% solids capture	Solids concentrations of 5% – 9%	Solids concentrations of 6% – 8%
	93% – 99% solids capture	95% – 98% solids capture
	Odors are contained/ Reduced odor potential	Odors are contained/ Reduced odor potential
	Low power consumption	Low power consumption
	Relatively small footprint -- smaller building requirement	Relatively small footprint -- smaller building requirement
Cons	**Cons**	**Cons**
Highest capital cost	Oils and greases can blind the drum filter media.	Oils and greases can blind the belt filter media
No well suited for Primary Sludge Thickening	Hydraulically limited. Largest unit is 400 gpm.	High wash water consumptions
Solids concentrations of 3% – 4%		
Energy intensive		
New technology/ unproven		
Odor nuisance/ Requires high volume of Odor Control		

7.3.4.2 Screening Criteria

The thickening technologies were screened to determine if the technologies met a minimum set of requirements. The screening process used a combination of pass/fail scoring and a high level rating on a scale of 1 to 5 for criteria identified in the previous sections. The results of the initial screening are provided in Table 7.3-3.

Table 7.3-3: Results of Initial Screening Evaluation

Thickening Alternatives	Weight	Gravity Thickener	DAFT	Centrifuge	Membrane	GBT	RDT
Supports Treatment and End Use Objectives	Pass/Fail	Yes	Yes	Yes	Yes	Yes	Yes
Meets Required Performance 5% Min (6% for 2-Phase Digestion)	Pass/Fail	Yes (No)	Yes	Yes	No	Yes	Yes
Proven Technology	Pass/Fail	Yes	Yes	Yes	No	Yes	Yes
Acceptable Complexity	Pass/Fail	Yes	Yes	Yes	No	Yes	Yes
Suitable for Separate or Co-Thickening	5%	1	4	3	1	4	4
Thickened Solids Concentration	30%	2	2	3	1	5	5
Solids Capture	20%	1	3	2	5	4	4
Footprint	10%	2	3	5	3	4	3
Polymer Usage	15%	4	3	3	5	1	2
Odor Control	10%	3	3	5	3	3	5
Power Requirements	5%	5	2	1	2	4	4
O&M Requirement	5%	5	4	2	1	3	3
Weighted Average		**2.5**	**2.8**	**3.1**	**2.9**	**3.7**	**4**

7.3.4.3 Screening Results

Gravity Thickeners and Membrane Thickeners were eliminated as potential alternatives through the initial screening because they failed to meet pass/fail criteria. Membranes are still a relatively new technology as applied to thickening. In the case of gravity thickening, in addition to the potential for low thickening solids concentration, the Agency expressed additional concerns with excessive odors and maintenance. The weighted average score was highest for RDT, followed by GBT. Centrifuge had a score more than 20% lower than RDT. DAFT scored 30% lower than RDT.

Although the Agency currently uses DAFTs successfully at existing facilities to thicken WAS, DAFTs are not well suited to thicken Primary Sludge separately and pose odor and maintenance concerns similar to Gravity Thickeners. However, due to the Agency's current successful operation and potential benefits of DAFTs, they were not screened out. DAFT, RDT, GBT and Centrifuges continued on to the more detailed evaluation.

7.3.5 Alternatives Development

7.3.5.1 Thickening System Performance Requirements

The performance goals shown in Table 7.3-4 will be used for the thickening technology evaluation only. These performance requirements are conservative and can potentially be achieved by all of the remaining four technologies. During detailed design, these can be refined based on IEUA objectives and related process selections.

Table 7.3-4: Thickening System Performance Goals

Performance Requirement	Value
Minimum thickened solids concentration	5% (6% for 2-Phase Digestion)
Minimum Solids Capture	95%

The following assumptions were made in evaluating the different thickening technology alternatives:

- Equipment sizing and facility layout are based on 2060 (build-out) projected flows and loads. Running costs, and repair and replacement are carried out to year 2045.
- Maximum day flows and loads were used to size the thickening facility to ensure facility is not hydraulically limited. If desired, during detail design, this assumption can be refined based on available equalization in upstream processes and to more closely match the Digestion facility.
- Thickening operation is assumed to be continuous, 24 hours per day/7 days per week.

7.3.5.2 Design Criteria and Equipment Sizing

Design criteria and sizing results for the four thickening alternatives are summarized in Tables 7.3-5 to 7.3-8. The design criteria for each alternative are based on the "Basis of Design Model" listed in the tables.

Table 7.3-5: DAFT Design Criteria

Design Parameter	Unit	Primary Sludge	WAS	Combined Sludge
Solids Loading Rate	$lb/ft^2/hr$	2.8	1.5	2.0
Air/ Solids Ratio	%	3	3	3
Air Input	scfm	50	30	70
Recycle Flow, total	gpm	4,470	2,490	5,910
Polymer Dosage	lb/dry ton	10	5	7.5
Basis of Design/ Tank Diameter		Ovivo 30-ft	Ovivo 30-ft	Ovivo 40-ft

Table 7.3-6: Centrifuge Design Criteria

Design Parameter	Unit	Primary Sludge	WAS	Combined Sludge
Hydraulic Loading Rate, max	gpm/unit	425	425	425
Solids Loading Rate, max	lb/hr/unit	3200	3200	3200
Polymer Dosage	lb/dry ton	3	8	5
Wash Water Requirement [a]	gpm	250	250	250
Basis of Design Model [b]		Alfa-Laval G3-125	Alfa-Laval G3-125	Alfa-Laval G3-125
Bowl Diameter	in	29	29	29

a. Intermittent Flow.

b. Per manufacturer's recommendation the medium size unit (G3-125) was selected over the larger unit (G3-165) because it results in lowest capital cost and is a more proven design.

Table 7.3-7: RDT Design Criteria

Design Parameter	Unit	Primary Sludge	WAS	Combined Sludge
Hydraulic Loading Rate, max	gpm/unit	400	400	400
Polymer Dosage	lb/dry ton	5	10	8
Wash Water Requirement	gpm	50	50	50
Basis of Design Model		Parkson RDT-400	Parkson RDT-400	Parkson RDT-400
Drum Diameter	in	44	44	44

Table 7.3-8: GBT Design Criteria

Design Parameter	Unit	Primary Sludge	WAS	Combined Sludge
Hydraulic Loading Rate	gpm/m	600	600	600
Solids Loading Rate	lb/hr/m	2600	2600	2600
Polymer Dosage	lb/ton	6	10	8
Wash Water Requirement	gpm	60	60	60
Basis of Design Model		Komline 3-m GBT	Komline 3-m GBT	Komline 3-m GBT

7.3.5.3 Alternatives Definition

A list of alternatives consisting of various combinations of technologies to handle Primary Sludge and Waste Activated Sludge separately or combined is presented below. As previously mentioned, DAFT was not considered for Primary Sludge thickening because of performance, odor, and maintenance concerns.

Separate Thickening:

- Alternative 1 – DAFT (WAS) + Centrifuges (PS)
- Alternative 2 – DAFT (WAS) + RDTs (PS)
- Alternative 3 – DAFT (WAS) + GBTs (PS)
- Alternative 4 – Centrifuges (Primary & WAS separately)
- Alternative 5 – RDTs (Primary & WAS separately)
- Alternative 6 – GBTs (Primary & WAS separately)

Co-thickening:

- Alternative 7 – DAFT (Combined)
- Alternative 8 – Centrifuges (Combined)
- Alternative 9 – RDTs (Combined)
- Alternative 10 – GBTs (Combined)

7.3.5.4 Unit Redundancy

For the DAFT alternatives, one large duty unit would be feasible, however, four smaller DAFT units that provide 33% capacity redundancy was preferred over one large duty unit and one large redundant unit, providing 100% redundancy that would sit empty most of the time. For Centrifuge, RDT and GBT alternatives, one full unit was assumed to provide redundancy in order to facilitate the thickening operations and maintain required capacity during extended maintenance events. In separate thickening alternatives for Centrifuge, RDT, and GBT, one redundant unit is setup to thicken either Primary Sludge or WAS.

Ancillary systems such as polymer, wash/spray water, conveyance and electrical will be designed to allow for operation of all thickening units (including standby) simultaneously in order to provide maximum operational flexibility.

7.3.5.5 Alternatives Sizing Results

Thickening equipment for the ten (10) BCE Alternatives are presented in Table 7.3-9. It is worth mentioning that in most cases the number of units required in 2060 did not vary from that required in 2045. This is because the population growth projection is linear up to 2045 and from 2045 to 2060 it is assumed to slow down considerably.

Table 7.3-9: Separate Thickening Alternatives Number of Units

Total Number of Units for each Alternative	2025			2045			2060		
Separate Thickening @ Max Day	PS	WAS	Total	PS	WAS	Total	PS	WAS	Total
Alternative 1 - DAFTs (WAS) + Centrifuges (PS)	4	3	7	5	4	9	5	4	9
Alternative 2 - DAFTs (WAS) + RDTs (PS)	4	3	7	5	4	9	5	4	9
Alternative 3 - DAFTs (WAS) + GBTs (PS)	3	3	6	4	4	8	4	4	8
Alternative 4 - Centrifuges (Primary & WAS)	4	1	5	5	2	7	5	2	7

Total Number of Units for each Alternative	2025			2045			2060		
Separate Thickening @ Max Day	PS	WAS	Total	PS	WAS	Total	PS	WAS	Total
Alternative 5 - RDTs (Primary and WAS)	4	2	6	5	2	7	5	2	7
Alternative 6 - GBTs (Primary and WAS)	3	1	4	4	2	6	4	2	6

a. Total number of units includes 1 standby unit. When using the same technology for the different stream, the standby unit is included in the count for Primary Sludge units.

Table 7.3-10: Co-thickening Alternatives Number of Units

Total Number of Units for each Alternative	2025	2045	2060
Co-Thickening @ Max Day	Total	Total	Total
Alternative 7 - DAFT	3	4	4
Alternative 8 - Centrifuge	4	6	6
Alternative 9 - RDT	4	6	6
Alternative 10 - GBT	3	4	5

a. Total number of units include duty units plus one standby unit.

7.3.5.6 Alternatives Layout

Layouts for each thickening alternative were developed to identify any space constraints that would rule out an alternative. No space constraints were identified. A facility layout of the selected technology, as modified to represent the Approved Project, is included in Chapter 2 of this Volume.

7.3.6 Thickening Alternatives Business Case Evaluation

Inputs and assumptions for the thickening BCE were developed in more detail in collaboration with IEUA staff. These are presented in the subsequent sections. The IEUA standard BCE template was utilized to develop comparative net present values for thickening facilities with construction starting in 2022 and operating through 2045.

7.3.6.1 Capital Costs

Capital costs for major pieces of equipment are project specific and were obtained from local manufacturer's sales representatives.

7.3.6.2 Operation and Maintenance (O&M) Costs

O&M assumptions were obtained from manufacturers and supplemented with information from previous projects.

Costs for energy consumption, water consumption, and polymer were obtained from the IEUA.

Labor costs and maintenance cost on a full-time equivalent (FTE) basis were also provided by the IEUA.

7.3.6.3 Repair and Replacement Costs

Cost for wear parts and hours for replacement were obtained from manufacturers and supplemented with information from previous projects.

One full unit was assumed to be replaced within the 23-year period for this BCE.

7.3.6.4 Risks and Benefits

No risks or benefits were included in this BCE.

7.3.6.5 Business Case Evaluation and Analysis

A summary of the results of the BCE are presented in Table 7.3-11. All costs are in 2016 dollars. The full BCE spreadsheets are presented in Exhibit I of this Volume.

DAFT and Centrifuges alternatives are cost-prohibitive due to the high cost of the equipment, high energy consumption, and high parts replacement costs. Rotary Drum and Gravity Belt Thickening are similar in terms of capital and annual O&M costs, but RDT has lower repair and replacement costs. Even though GBT alternatives require one less unit than RDTs, the units are more expensive and larger, requiring more physical space in a solids thickening facility.

Polymer consumption is not a differentiator between alternatives. The recommended polymer dosage for all equipment was within the range of 0 to 10 lb/dry ton.

The most cost-effective technology based on this BCE is co-thickening with RDTs. However, depending on the actual polymer dosage requirements established after bench scale testing of the different sludge streams, separate thickening may prove more cost-effective.

Table 7.3-11: Results of the Business Case Evaluation

	Alternative	Capital (1)	O&M (2)	R&R (2)	NPV
1	DAFT (WAS) and Centrifuges (PS)	$32,200,000	$25,800,000	$2,500,000	$(62,400,000)
2	DAFT (WAS) and RDT (PS)	$24,200,000	$18,800,000	$1,400,000	$(45,700,000)
3	DAFT (WAS) and GBT (PS)	$25,800,000	$19,900,000	$2,000,000	$(49,100,000)
4	Centrifuges Separate	$25,000,000	$21,600,000	$2,100,000	$(50,200,000)
5	Rotary Drum Thickener Separate	$12,800,000	$12,700,000	$600,000	$(26,800,000)
6	Gravity Belt Thickener Separate	$14,500,000	$15,900,000	$1,400,000	$(32,600,000)
7	DAFT Co-thickening	$19,100,000	$30,600,000	$1,100,000	$(51,900,000)
8	Centrifuges Co-thickening	$21,500,000	$22,400,000	$1,700,000	$(46,700,000)
9	Rotary Drum Thickener Co-thickening	$11,200,000	$14,000,000	$600,000	$(26,400,000)
10	Gravity Belt Thickener Co-thickening	$11,900,000	$14,900,000	$1,100,000	$(28,500,000)

(1) Capital costs shown are un-escalated 2016 dollars
(2) O&M and R&R costs shown are escalated and discounted back to 2016 dollars.

7.3.7 Agency Decisions and Preferences for the Approved Project Requirements

During the BCE workshop on August 11, 2016, IEUA provided some direction and preferences that are not part of the BCE but will be included in the Approved Project deliverable. The BCE was only updated to address comments that would have the potential for affecting the technology selection. The impact on the selected thickening equipment size, number, layout, and cost will be evaluated at the next detailed design phase of the project.

Major items to be integrated into the final Approved Project Requirements include:

- Thickening equipment phasing.
- Thickening building layout refinements. Sufficient space around thickening units to facilitate easy maintenance and operation.
- Flexibility to separately thicken Primary Sludge and WAS or co-thicken based on the Agency's goals.
- The thickening facility sludge storage tanks (raw and thickened sludge) will be sized to allow operation of the thickening and sludge transfer equipment over all anticipated facility loading rates.
- Ranges of performance of thickening equipment (i.e., higher %TS of thickened sludge) needs to be accommodated by pumping and conveyance downstream of thickening units.
- Emulsion polymer is preferred over dry polymer systems as it provides the Agency with more polymer options based on their current contracts.

The Agency staff also expressed a desire to visit an operating RDT facility to better understand design and operational details that will help inform their ultimate design preferences leading to optimization of the design at the next stage of the project.

7.3.8 Recommendations

Based on the BCE favoring RDTs by a considerable margin for both separate thickening and co-thickening scenarios, selection of RDT is recommended for solids thickening. Because the difference between separate thickening and co-thickening is small and heavily depends on the polymer dosage assumed for each stream, it is recommended that the Thickening Facility be sized for the seven (7) RDT units required for separate thickening through build-out and provide the piping arrangement required to allow for separate thickening or co-thickening. This recommendation was approved by the IEUA at the BCE workshop on August 11, 2016.

7.4 EVALUATION OF RP-5 SOLIDS DIGESTION ALTERNATIVES

7.4.1 Introduction

This introductory section presents a project background, understanding and approach, and a list of the anaerobic digestion alternatives evaluated using a BCE for evaluation of the IEUA RP-5 solids digestion facility alternatives.

Based on the background of the project, the new solids treatment facility at RP-5 would consist of Thickening, Digestion, and Dewatering. This chapter describes the BCE of three different alternatives for the digestion facility to arrive at the most cost-effective option.

The purpose of the BCE is to provide sufficient comparative information on costs, benefits, and risks of the alternatives to provide a sound basis for technology selection. Sizing, loading, process configurations, layouts, and costs are based on project parameters agreed on by the project team and Agency staff at the time of commencing the BCEs for the 2045 design year. Because evaluations of technologies and other important project conditions were conducted in parallel and results can impact the final configurations, refinement of the final selected alternative and costs will be conducted after the BCE and technology selection described in this chapter are completed. This refinement will be reflected in the Approved Project Requirements document and integrate into the design final decisions made by the Agency on project phasing, final load decisions related to FW and FOG treatment, staff layout and configuration preferences, and other decisions subsequent to the BCE.

The following are the three alternatives considered for the digestion facility:

- Mesophilic Anaerobic Digestion (MAD)
- Two-Phase Anaerobic Digestion (2-Phase)
- Thermal Hydrolysis Process Anaerobic Digestion (THP)

7.4.2 Solids Feed Characteristics and Production

This section describes solids feed characteristics Projections for the solids flows and loads to the digestion facility.

7.4.2.1 Solids Feed Characteristics

The solids feed characteristics that will impact digestion are summarized in Table 7.4-1.

Table 7.4-1: Projected Digestion Feed Characteristics

Sludge Characteristic	Average Value
Nominal Sludge Composition, Total Dry Solids Weight Basis	Anaerobically digested blend of primary sludge, WAS, FW, and FOG
Primary sludge and WAS feed, %volatile solids (%VS) dry mass basis	70
Food waste and FOG to digester feed, %VS dry mass basis	30
Total solids concentration, %TS, MAD, 2-Phase	5
Total solids concentration, %TS, THP [a]	16.5
Volatile solids (VS), % dry mass basis	86
Temperature, deg F	65 – 85
Average pH	7

a. After pre-dewatering facility

7.4.2.2 Solids Flows and Loads

Projections for the solids flows and loads to the digestion facility following solids thickening for both the maximum day and maximum 2-week conditions have been developed. Table 7.4-2 provides a summary of these solids loads for 2025, 2045, and 2060. The values shown in Table 7.4-2 are for overall combined sludge which includes food waste, FOG and combined sludge (Primary Sludge and WAS). Sludge projections are based on the plant influent flow of both RP-5 and CCWRF.

Table 7.4-2: Digestion Solids and Hydraulic Loading Projections

Performance Parameter		2025	2045	2060
Influent Flow, mgd[a] (RP-5 and CCWRF)		23.6	35.8	38.5
Solids Loading, ppd[b]	Max Day	149,400	221,700	237,900
	Max 2-Week	140,100	207,900	223,100
VS Loading, ppd	Max Day	128,500	190,600	204,600
	Max 2-Week	120,500	178,800	191,800
Hydraulic Loading, gpd[c]	Max Day	313,800	465,600	499,700
	Max 2-Week	291,500	432,600	464,300
Sludge VS, % VS		86		

a. million gallons per day

b. pounds per day

c. gallons per day

7.4.3 Digestion Technology Alternatives Descriptions

7.4.3.1 Mesophilic Anaerobic Digestion (MAD)

The majority of MAD systems currently in use at municipal wastewater treatment plants (WWTPs) for solids stabilization are configured as conventional mesophilic anaerobic digesters. The mesophilic temperature range is approximately 36°C–38°C where heating and mixing are provided to maintain uniform conditions in the digester. In a conventional mesophilic digestion operation, storage tanks are normally included for digested sludge prior to dewatering. Properly configured, a storage tank can also function as a digester in the event that the primary digester is out of service, provided the necessary heating and mixing equipment is installed. MAD is the industry standard for anaerobic digestion and represents the base case for the BCE. A process flow diagram (PFD) for the MAD process is provided in Figure 7.4-1.

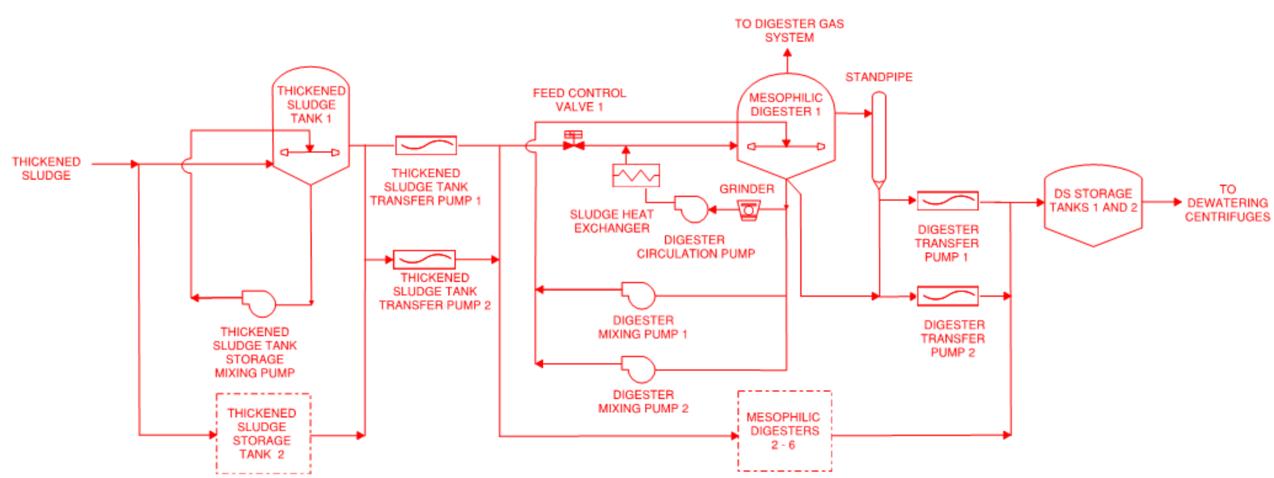


Figure 7.4-1: MAD PFD

7.4.3.2 Two-Phase Anaerobic Digestion (2-Phase)

Two-phase Acid/Gas (2-Phase) digestion is a two-stage digestion process comprising acid and gas phase digesters. The first digester in the series is operated with a short SRT of 1.5 days to 2 days, during which the substrates are hydrolyzed to produce volatile fatty acids (VFAs). Methanogens require a longer SRT and are thus excluded from this acid-phase digester (aka acid silo), which can be at either thermophilic or mesophilic temperature. The VFAs are then used by methanogens in the second digester. This separation in phases has been demonstrated through long-term operation by the IEUA to improve solids reduction and increase gas production. A PFD for 2-Phase digestion process is provided in Figure 7.4-2.

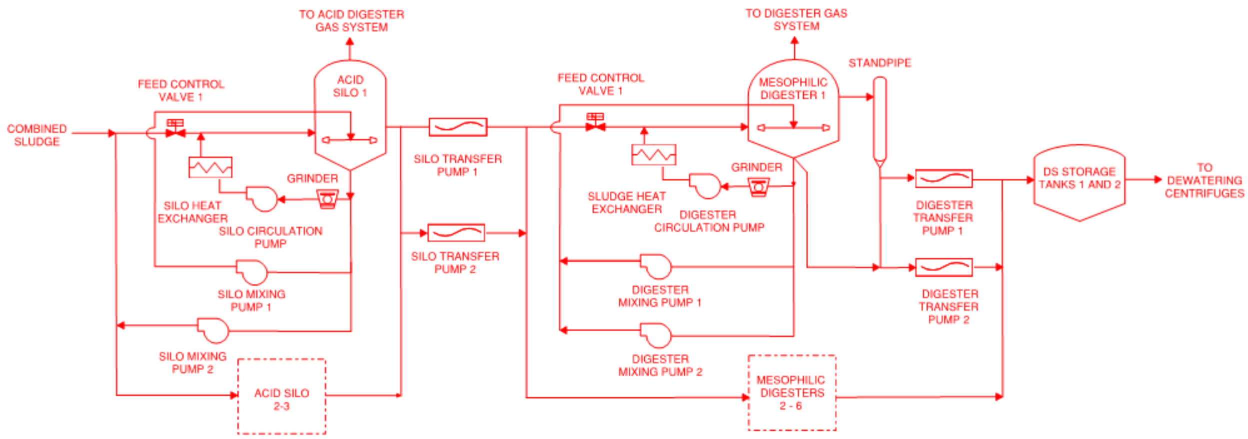


Figure 7.4-2: Two-Phase Anaerobic Digestion PFD

7.4.3.3 Thermal Hydrolysis Process (THP)

Thermal hydrolysis is a high-heat, high-pressure anaerobic digestion pretreatment system that results in enhanced solids processing and energy production and has the benefit of reducing pathogens to Class A levels through pasteurization/sterilization and improved dewaterability. THP is an evolving technology that uses steam to put solids under high temperature and pressure conditions, which lyse bacterial cells and promote the release and solubilization of particulate organic material. THP also tends to hydrolyze large biological macromolecules, carbohydrates, and long-chain fatty acids to lower molecular weight intermediates, making them more amenable to digestion, improving volatile solids reduction and biogas production. To make the process efficient, raw feed solids are pre-dewatered before the THP process and the anaerobic digesters are operated at a higher solids concentration than other digestion processes such as MAD and 2-Phase. A process flow schematic is provided in Figure 7.4-3.

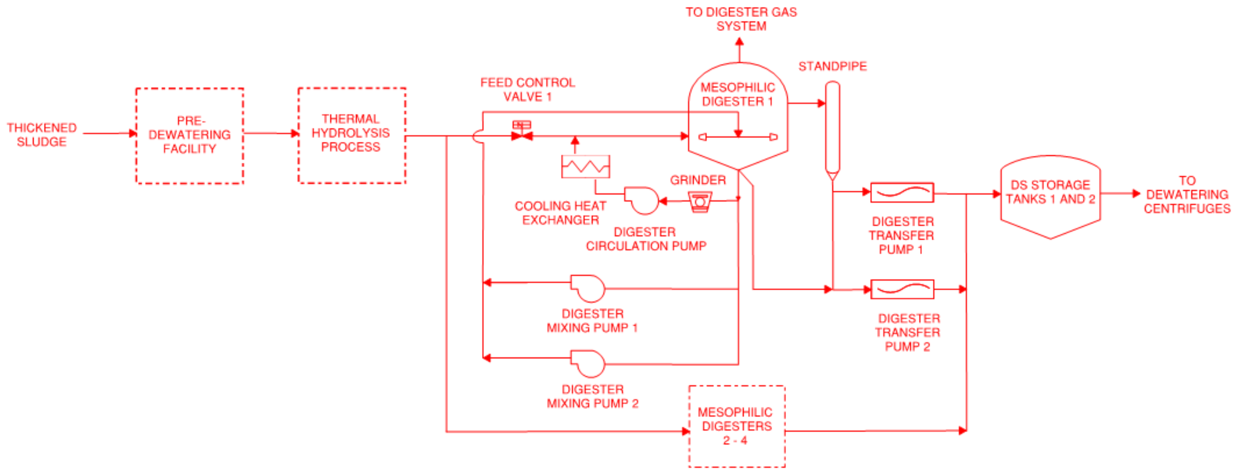


Figure 7.4-3: THP PFD

7.4.4 Alternatives Screening

7.4.4.1 Screening Criteria

The following digestion technologies were initially screened to determine if all technologies meet IEUA minimum requirements using a pass/fail approach:

- Mesophilic Anaerobic Digestion (MAD)
- 2-Phase Anaerobic Digestion (2-Phase)
- 3-Phase Anaerobic Digestion
- Temperature-Phased Anaerobic Digestion (TPAD)
- Thermal Hydrolysis Process (THP)

A high level rating on a scale of 1 to 5 (with 5 being the most favorable score) was also provided for criteria considered important and weighted averages computed. The results are provided in Table 7.4-3.

Table 7.4-3: Results of Initial Screening Evaluation

Parameters	Weight	MAD	3-Phase	2-Phase	TPAD	THP
Supports Treatment and End Use Objectives	Pass/Fail	YES	YES	YES	YES	YES
Meets Required Performance	Pass/Fail	YES	YES	YES	YES	YES
Proven Technology	Pass/Fail	YES	YES	YES	YES	YES
Acceptable Complexity	Pass/Fail	YES	YES	YES	YES	YES
Performance (VSR[a], Gas Production)	15%	3	4	4	4	4

Energy/Resource Recovery	10%	3	4	4	4	4
O&M Impacts	10%	5	3	4	3	1
Safety Impacts	10%	4	4	4	4	2
Environmental Impacts – Cake Stability, Pathogens	5%	3	4	3	4	5
Potential Odor Impacts	5%	4	3	3	3	2
Flexibility	10%	4	4	4	4	2
Site Space Utilization	15%	4	3	3	3	5
Food Waste Compatibility	5%	3	5	4	5	2
Relative Cost	15%	5	3	4	3	3
Weighted Average Score[b]		**3.9**	**3.6**	**3.8**	**3.6**	**3.1**

a. volatile solids reduction

b. Note: higher weighted average scores are most favorable

The IEUA desires that the digestion facility is provided with the ability to operate at either mesophilic or thermophilic temperatures. Given this preference, both the 3-Phase and TPAD alternatives were removed from further evaluation. Either the mesophilic digestion or 2-Phase options could be operated as either TPAD or 3-phase given the ability to operate at either mesophilic or thermophilic temperatures. THP was included for consideration due to the ability of this technology to reduce footprint requirements and provide a desirable Class A product.

7.4.4.2 Screening Recommendation

All digestion technology alternatives met the pass/fail criteria and advanced. Three technologies were carried forward for the BCE analysis: MAD, 2-Phase, and THP alternatives. The 3-Phase and TPAD technologies were not carried forward as these processes could be easily accommodated by either the Mesophilic or 2-Phase technologies given the ability to operate the digesters at either mesophilic or thermophilic temperatures (assumption for thermophilic option would include installation of higher capacity heat exchangers, comprehensive thermal insulation of tanks and covers, and other necessary improvements).

7.4.5 Alternatives Development

This section describes the development of the digestion technology alternatives.

7.4.5.1 Digestion System Performance Requirements

The performance requirements shown in Table 7.4-4 will be used for the digestion technology evaluation only. These design performance requirements will be refined based upon IEUA objectives and related process selections during detailed design.

Table 7.4-4: Digestion System Performance Requirements

Performance Requirement [a]		MAD	2-Phase		THP
			Acid	Gas	
Solids retention Time, days	Max[d] 2-Week	15	-	14	12
	Max Day	-	1	-	-
Organic Loading Rate, lb[b] VS/ft[3c]-day	Max 2-Week	0.18	-	0.2	0.35
	Max Day	0.24	3	0.27	0.5

a. Values based on WEF MOP 8 and Industry Standard Design Practices.

b. Pound

c. Cubic foot

d. Maximum

The following assumptions were used in evaluating the digester alternatives:

Digesters sizing and site layouts are based on year 2060 (build-out). BCE will be carried out to year 2045.

- Max 2-week flows and loads are used to size digestion facility for Mesophilic, 2-Phase, and THP facility digesters.
- Acid reactors sized for max day.

7.4.5.2 IEUA Digestion Technology Preferences

IEUA defined several preferences for the digestion technology, as follows:

- Proven 2-phase digestion to maximize digestion performance and gas production
- Redundant digester
- Continuous digester feeding
- Fixed digester cover
- Ability to operate in thermophilic mode
- Digested Solids (DS) storage tank(s) to operate as digester if needed in the future
- FOG and FW digestion; design impacts without FW and FOG will be evaluated as part of the approved project
- Future treatment of digestate from RP-5 solids handling facility (SHF) may be required
- All indoor equipment and galleries
- Operator familiarity with equipment
- Equipment repair downtime must be low; facilities requiring manufacturer services facilities must be capable of quick response with spare primary and critical equipment components stocked at the facility or quickly available through a manufacturer exchange program
- Capable of fully automatic operation with limited operator observation
- Preference towards fewer equipment items to limit maintenance requirements and complexity
- Low equipment repair/component replacement frequency
- Low daily maintenance and housekeeping requirement

7.4.5.3 Alternatives Performance and Sizing

The performance and sizing results for the three digestion alternatives are summarized in Tables 7.4-5 to 7.4-7 and were used as the basis for developing the digestion technology BCE.

Note that for the MAD and THP processes the controlling condition is the 2060 VS load. For the Two-Phase process the controlling condition is the 2060 SRT for the acid reactor at one tank out of service and the VS load for the methane reactor.

Table 7.4-5: Alternative 1- MAD Performance and Sizing Data

Design Condition	2025	2045	2060
Digester tank volume and number			
Digester Feed Tank Volume, mgal each	0.13	0.13	0.13
Digester Feed Tank Number	2	2	2
Digester Volume, mgal each[a]	1.6	1.6	1.6
Digester Tank Number	4	6	6
Digester SRT, day			
Max 2-week, all in service	21.9	22.1	20.6
Max 2-week, one tank out of service	16.4	18.4	17.3
Digester VS Loading, lb/ft^3			
Max 2-week, all in service	0.14	0.14	0.15
Max 2-week, one tank out of service	0.19	0.17	0.18

a. At one tank out of service.

Table 7.4-6: Alternative 2 - Two-Phase Digestion Performance and Sizing Data

Design Condition	2025	2045	2060
Digester Tank Volume and Number			
Acid Tank Volume, mgal[a]	0.25	0.25	0.25
Acid Feed Tank Number	2	3	3
Digester Volume, mgal[a]	1.44	1.44	1.44
Digester Tank Number	4	6	6
Acid Digester SRT, day			
Max Day, all in service	2.4	1.6	1.5
Max Day, one tank out of service	1.6	1.1	1.0
Gas Digester SRT, day			
Max 2-week, all in service	19.7	19.9	18.6
Max 2-week, one tank out of service	14.8	16.6	15.5
Acid Digester VS Loading, lb/ft^3			
Max Day, all in service	1.3	1.9	2.0
Max Day, one tank out of service	1.9	2.8	3.0
Gas Digester VS Loading, lb/ft^3			
Max 2-week, all in service	0.16	0.16	0.17
Max 2-week, one tank out of service	0.2	0.19	0.2

a. At one tank out of service.

Table 7.4-7: Alternative 3 - THP Performance and Sizing Data

Design Condition	2025	2045	2060
Digester tank volume and number			
Digester Volume, mgal[a]	1.37	1.37	1.37
Digester Tank Number	3	4	4
Digester SRT, day			
Max 2-week, all in service	25.9	23.3	21.7
Max 2-week, one tank out of service	17.3	17.5	16.3
Digester VS Loading, lb/ft^3			
Max 2-week, all in service	0.22	0.24	0.26
Max 2-week, one tank out of service	0.33	0.33	0.35

a. At one tank out of service.

7.4.5.4 Subjective Equipment Considerations

Subjective considerations for the three digestion technology alternatives were presented for consideration as part of the selection process and are provided below.

The advantages and disadvantages of the MAD, 2-Phase, and THP digestion alternatives are summarized in Table 7.4-8 through Table 7.4-10.

Table 7.4-8: MAD Equipment Considerations

Advantages	Disadvantages
• Longest operational history of all the processes under consideration. • Most supporting operational data. • Produces class B solids with minimal amount of additional testing or processing. • Digester performance and gas production rates can be easily predicted from MAD systems. • Process can easily be upgraded to an advanced digestion process, such as 2-Phase, 3-phase, or THP.	• Degradation rates are relatively low. • Foaming potential. • Process upset potential (temperature and loading rate sensitive). • Lower VS destruction, low gas production, more tankage volume required. • Additional mass of solids for disposal relative to two other processes.

Table 7.4-9: Two-Phase Equipment Considerations

Advantages	Disadvantages
• Higher loading rate allows for slightly smaller digesters • For class A biosolids, 2-Phase can be run as TPAD by operating acid reactor at thermophilic temperatures. • Improved VSR and gas production. • Process can easily be upgraded to an advanced digestion process, such as 3-phase or THP.	• Gas from acid phase reactor requires more extensive treatment than not blended with methane phase gas. • Excessive retention times in the acid phase may increase odorous compounds including Hydrogen Sulfide (H_2S) gas. • These compounds impact the life or performance of gas utilization equipment and may generate odors at flares. • Biogas produced in Acid Phase reactor is of low quality and requires either a thermal oxidizer flare or bending with higher quality biogas from mesophilic digester gas

Table 7.4-10: THP Equipment Considerations

Advantages	Disadvantages
• Highest wastewater solids processing capacity and greatest VSR. • THP also increases extent of VSR and gas production.	• Ancillary systems & equipment such as steam boilers, pre-dewatering centrifuges, raw cake storage and sludge cooling systems impact the total cost, complexity and footprint.

• THP decreases viscosity of digester feed sludge allowing the feed solids range from 9%-12% thereby allowing for a reduced digester residence time. • Volumetric solids loading rate to the digestion process is increased and SRT decreased, increasing the solids handling capacity of a given digester volume or reducing number of new digesters installed. • Solids from THP exhibit improved dewaterability, less odorous cake and Class A biosolids.	• Increased concentration of ammonia in digester with potential inhibition of digestion and impacts from high ammonia concentrations in dewatering recycles. • Formation of recalcitrant dissolved organic nitrogen (rdoN) may occur under certain operation conditions.

The comparative summary of the three digestion alternatives is provided in Table 7.4-11.

Table 7.4-11: Comparative Summary of Digestion Alternatives

Alternatives	Footprint	Biogas Production	Utilities	Odor Potential	Biosolids Quality	Costs		Experience
						Capex	Opex	
MAD	Avg[a]	Avg	Avg	Avg	Avg	Avg	Avg	High
2-Phase	Avg	Above Avg	Above Avg	High	Avg	Above Avg	Above Avg	IEUA standard
THP	Below Avg	Avg	High	High	High	High	High	Limited in USA, strong growth

a. Average

7.4.5.5 Redundancy Discussion

In order to provide redundancy for digestion alternatives, the following options are provided:

- Additional digester tank for all options.
- Additional acid phase tank for 2-Phase digestion process
- Redundant mixing provided by standby pump and HEX recirculation pump for all options
- Dedicated or shared standby pumps for all options
- Additional heat exchanger (HEX) capacity and tank insulation will allow either alternative to operate in TPAD mode
- Digested sludge storage tank can be sized/configured to operate as a standby anaerobic digester

7.4.6 Digestion Alternatives Business Case Evaluations

7.4.6.1 Cost Estimates

Capital, annual running (O&M), repair and replacement (R&R), and risk and benefit costs were estimated collaboratively with IEUA staff for the three digestion alternatives described in this chapter. The IEUA standard BCE template was used to develop comparative NPVs for digestion facilities constructed in 2022 and operating through 2045. Capital costs were developed for 2045 but also represents for 2060 costs since the number and size of equipment are the same for both 2045 and 2060 due to only a modest increase in solids loadings between 2045 and 2060.

The results of the BCE are based on the following assumptions:

- Capital cost for major equipment components were obtained from manufacturers.
  - MAD, 2-Phase: Covers recent quotes for 85-ft Tank. Digester mixing pumps based on a Vaughan Rotamix equipment quotation. Other equipment based on separate vendor data and past projects.
  - THP: Based on vendor data and recent/ongoing projects; Centrifuges based on Andritz quote for D7LL unit.
- O&M Costs:
  - Maintenance and operation assumptions were obtained from manufactures and previous projects.
  - Costs for energy consumption, water consumption, and polymer were obtained from the IEUA.
  - Labor costs and maintenance cost on an FTE basis were also provided by the IEUA.
- R&R Costs: Cost for repair and replacement were calculated based on service life of each equipment:
  - Valves: 10 years
  - Pumps, piping, and other small equipment: 20 years
  - Large equipment (digester covers, flares): 30 years
- Risk and Benefit: Benefits of dewatering from THP, and dewatering and gas production from 2-Phase digestion were included in this BCE.
- Life-Cycle Benefit/Cost Analysis: Based on NPV, which included an escalation rate = 3% and discount rate = 2%.

7.4.6.2 Business Case Evaluation Results and Analysis

Results of the BCE for the digestion alternatives under evaluation in this report are provided below in Table 7.4-12. All costs are in 2016 dollars. The full BCE spreadsheets are presented in Exhibit I of this Volume.

Table 7.4-12: Results of the Anaerobic Digestion Alternative Business Case Evaluation

Alternatives	Capital (1)	O&M (2)	R & R (2)	Risk and (Benefit)	NPV
1 MAD	$70,300,000	$65,512,000	$11,661,000	-	$152,480,000
2 Two-Phase	$61,100,000	$72,986,000	$12,947,000	($13,060,000)	$135,010,000
3 THP	$116,500,000	$142,557,000	$29,072,000	($26,136,000)	$274,250,000

(3) Capital costs shown are un-escalated 2016 dollars
(4) O&M and R&R costs shown are escalated and discounted back to 2016 dollars.

Alternative 1, MAD, represents the base case for VSR efficiency and biogas production and is historically the lowest case capital option but at higher operating costs compared to advanced digestion alternatives discussed previously in this report. Alternative 2, Two-Phase digestion, has a higher capital cost (by 5.5% compared to MAD) but which is offset by benefits of improved biosolids dewatering resulting in lower hauling costs and improved VSR and biogas production. Operational data collected by the IEUA indicates 2-Phase digestion has higher biogas production (16 ft^3 per lb for VSR compared to 15 for MAD) and higher VSR (58% compared to 55% for MAD). The combination of these two factors resulted in a 12.1% increase in biogas production over MAD and resulted in NPV equivalent to MAD. Alternative 3, THP, has the highest capital and operating cost but with benefits including better dewaterability leading to less sludge being hauled to disposal. A sensitivity analysis was performed and determined that BCE results are not sensitive to typical variables across digestion technology alternatives.

7.4.7 Agency Decision and Preferences for the Approved Project Requirements

The purpose of this section is to document recent IEUA direction/preferences provided during the BCE workshop on August 11, 2016. These preferences will not impact the comparative decision making process provided through the BCE analysis.

Major items to be integrated into the final Approved Project Requirements include:

- Determine feasibility (capital and operating costs) of feeding FOG or FW to digesters.
- Evaluate digester facility phasing options to reduce capital expenditures for the initial project.
- Develop site layout alternatives for potential addition of future food waste, FOG, and SHF digestate.
- Determine phasing of thermophilic digestion capability; for example, determine if inclusion of equipment for thermophilic operation should be installed for the initial project or phased into a future project.
- Evaluate impact of configuring DS storage tank(s) as anaerobic digesters on the number and size of anaerobic digesters required for the initial project while meeting the 2060 buildout requirements.
- Evaluate the potential to optimize digester size and/or performance (i.e., longer SRTs, VSR exceeding 0.18 lb/ft^3 loading criteria) by increasing thickening performance using RDTs to increase feed solids concentration to digestion (i.e., 5.5% instead of 5%, or potentially higher %TS).
- Evaluate digester mixing systems other than jet mixing system, including draft tube and gas mixing to determine the optimal mixing system for the 2-Phase anaerobic digestion process.
- Evaluate egg-shaped digester as an option to either silo or pancake shapes in terms of impacts to site layout, and capital and O&M costs. Include the potential effect of the high-voltage power lines running along the eastern boundary of the site. Safety issues for working near the power lines may present important constraints for using construction

cranes necessary for constructing tall digestion tanks, and their maintenance if/when cranes are needed.

- Evaluate surface withdrawal and additional cover options to address foaming issues.

7.4.8 Recommendation

Because of the IEUA's favorable experience with 2-Phase digestion, the improved biogas production and increased digestion efficiency, and the BCE results show 2-Phase equal to MAD, 2-Phase digestion is recommended. This recommendation was approved by the IEUA at the BCE workshop on August 11, 2016. To provide ability for future 3-Phase operation, the digestion system should be designed to be capable of either mesophilic or thermophilic operation.

7.5 EVALUATION OF RP-5 SOLIDS DEWATERING ALTERNATIVES

7.5.1 Introduction

This introductory section presents a project background, understanding and approach, and a list of solids dewatering alternatives evaluated using a BCE.

Based on the background of the project, the new solids treatment facility at RP-5 would consist of Thickening, Digestion, and Dewatering.

This section describes the BCE of three different alternatives for digested solids dewatering to arrive at the most cost-effective option.

The purpose of the BCE is to provide sufficient comparative information on costs, benefits, and risks of the alternatives to provide a sound basis for technology selection. Sizing, loading, process configurations, layouts, and costs are based on project parameters agreed on by the project team and Agency staff at the time of commencing the BCEs. Since evaluations of technologies and other important project conditions were conducted in parallel and results can impact the final configurations, refinement of the final selected alternative and costs will be conducted after the BCE and technology selection described in this chapter. This refinement will be reflected in the Approved Project Requirements document and integrated into the design final decisions made by the Agency on project phasing, final load decisions related to FW and FOG treatment, staff layout and configuration preferences, and other decisions subsequent to the BCE.

The following are the alternatives considered for dewatering:

- Centrifuge
- Belt Filter Press (BFP)
- Screw Press

7.5.2 Solids Feed Characteristics and Production

7.5.2.1 Solids Feed Characteristics

The solids feed characteristics from anaerobic digestion that may impact dewaterability are summarized in Table 7.5-1. Projected average values are provided to facilitate comparison of dewatering technologies.

Table 7.5-1: Projected Dewatering Feed Characteristics

Sludge Characteristics	Value
Nominal Sludge Composition, Total Dry Solids Weight Basis	Anaerobically digested blend of primary sludge, WAS, FW, and FOG
Total solids concentration, %TS	2.8
Volatile solids (VS), % dry mass basis	69
Temperature, deg F	85–100
Average pH	7

7.5.2.2 Solids Flows and Loads

Projections for the solids flows and loads from anaerobic digestion to dewatering for both the maximum month and annual average conditions have been developed. Table 7.5-2 provides a summary of these solids loads for 2025, 2045, and 2060.

Table 7.5-2: Dewatering Solids and Hydraulic Loading Projections

Loading Condition	2025	2045	2060
Maximum month solids loading, dry lb TS/day	56,700	84,200	90,400
Maximum month hydraulic loading, gpd @ 2.8 %TS	247,400	367,100	394,000
Annual average solids loading, dry lb TS/day	42,800	63,500	68,200
Annual average hydraulic loading, gpd @ 2.8 %TS	183,300	272,100	292,000

7.5.3 Solids Dewatering Technology Alternatives Descriptions

7.5.3.1 Centrifuge

A centrifuge is composed of two cylinders, rotating at slightly different speeds. In the outer cylinder, centrifugal force propels the heavier digested solids to the wall of the outer cylinder at accelerations of approximately 3,000 gravitational units (G's). Centrate, the remaining residual liquid, accumulates along the axis of rotation and is discharged over a concentric weir. The inner cylinder has a scroll encircling its outer surface. Because the inner cylinder rotates at a slightly slower rotational speed than the outer cylinder (the differential), the scroll moves along the inner surface of the outer cylinder, conveying the dewatered solids to a dewatering beach, and then to its discharge. The liquid centrate is conveyed via an overflow weir to a liquid drain. A picture of a dewatering centrifuge is presented below in Figure 7.5-1.

Figure 7.5-1: Dewatering Centrifuge

Image courtesy of Alfa Laval

7.5.3.2 Belt Filter Press (BFP)

A BFP is a dewatering device that applies mechanical pressure to chemically conditioned sludge slurry sandwiched between two tensioned belts by passing those belts through a serpentine of decreasing-diameter rolls. The machine can be divided into three zones:

- Gravity zone: free-draining water is drained by gravity through a porous belt
- Wedge zone: solids are prepared for pressure application
- Pressure zone: medium and then high pressure is applied to the conditioned solids

The serpentine pathway of the belts also imparts shear to the compressed solids, further aiding in dewatering. A photograph of a typical BFP is shown in Figure 7.5-2.

Following conditioning with polymers, the sludge is first discharged onto a gravity section (analogous to a gravity belt thickener), where the free liquid drains through the filter cloth. In Figure 7.5-2, this section is located along the top of the BFP. The gravity belt can be a separate cloth with different porosity from the other belts (in a three-belt design), or it becomes either the top or bottom belt (two-belt design). The top and bottom belts envelop the gravity-drained sludge and feed it into a series of rollers that gradually compress the sludge, displacing the water.

Figure 7.5-2: Belt Filter Press

Image courtesy of Komline-Sanderson

The gravity belt section discharges thickened sludge into the wedge section, where the sludge is captured between the top and bottom belts prior to entering the wedge section. The belt/sludge/belt sandwich is then fed to the high-pressure zones. Multiple drive rollers, belt washers, and belt steering (tracking) rollers are provided within the BFP. Operational adjustments include feed rate, belt speed, belt tension, belt type, and wedge adjustment.

Polymer addition and polymer/sludge mixing also critical factors. Excessive turbulence downstream of polymer/sludge mixing can deflocculate the conditioned sludge, resulting in degraded solids capture and increased solids in the recycle stream. A flocculation tank is typically provided (see Figure 7.5-2) immediately upstream of the BFP gravity drainage section.

7.5.3.3 Screw Press

The screw press forces flocculated digested sludge through a porous drum with a flighted expanding shaft diameter screw. The screw press may be horizontal or inclined and works according to the dewatering principles of gravity and mechanical compression. The screw press drum is provided with opening spacing and sizing that can vary by manufacturer. The screw conveys the sludge slowly through the drum exerting increasing mechanical pressure as the screw shaft diameter increases. The screw speed is adjustable for operational flexibility. Back-pressure may be added by an adjustable discharge zone to further increase dewatering performance. An image of a typical screw press is presented in Figure 7.5-3.

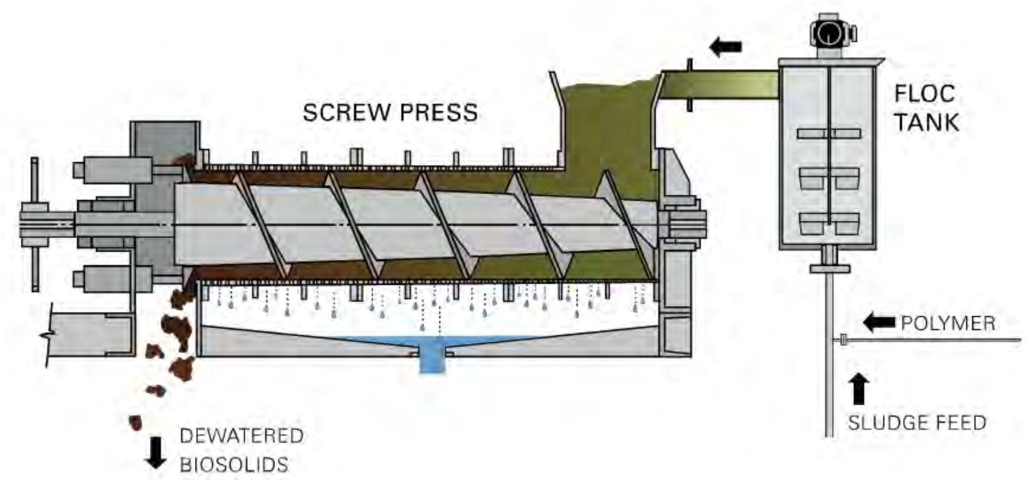


Figure 7.5-3: Screw Press

Figure courtesy of FKC Co., Ltd.

7.5.4 Alternatives Screening

7.5.4.1 Screening Criteria

The dewatering technologies were initially screened to determine if all technologies meet IEUA minimum requirements using a pass/fail approach. A high level rating on a scale of 1 to 5 was also provided for criteria considered important and weighted averages computed. The results are provided in Table 7.5-3.

Table 7.5-3: Results of Initial Screening Evaluation

Dewatering Alternatives	Weight	Centrifuge	Belt Filter Press	Screw Press
Supports Treatment and End Use Objectives	Pass/Fail	YES	YES	YES
Meets Required Performance	Pass/Fail	YES	YES	YES
Proven Technology	Pass/Fail	YES	YES	YES
Acceptable Complexity	Pass/Fail	YES	YES	YES
Number of Units Required	5%	5	3	1

Record of US Municipal Installations for Similar Size Unit	5%	5	5	2
Cake Solids Concentration	15%	5	3	4
Solids Capture	10%	5	5	4
Polymer Dose	15%	2	4	4
Power Requirement	10%	1	3	5
Footprint	10%	5	3	2
Operations and Maintenance Impacts	10%	4	3	5
Operator Exposure (noise, sound, process)	10%	4	2	5
Odor Control	5%	4	2	4
Washwater Requirements – Impact to Secondary Treatment Process	5%	5	2	4
	Weighted Average	**4**	**3.2**	**3.9**

7.5.4.2 Screening Recommendation

All dewatering technology alternatives met the pass/fail criteria and advanced. The weighted average score was highest for centrifuge with screw press nearly equal and BFP about 20% lower.

7.5.5 Alternatives Development

7.5.5.1 Operating Schedule

The IEUA has requested that the initial BCE consider a dewatering operating schedule of 8 hours per day, 5 days per week. After Agency staff reviewed and provided feedback on the initial BCE results, the screw presses' operation was revised to 24 hours per day, 5 days per week. Operation of centrifuges and BFPs was not altered and assumed to be 8 hours per day, 5 days per week.

It is important that equipment availability is maximized with limited downtime for routine cleaning and maintenance of dewatering equipment. It is also important to have a redundant dewatering unit to ensure processing capacity during extended machine downtime for maintenance.

7.5.5.2 Digested Sludge Holding Tank

A minimum of 3 days of maximum month digested sludge storage will be provided upstream of dewatering to provide operational flexibility and eliminate the need for dewatering over holiday weekends. An additional benefit of dedicated digested sludge storage volume is the ability to help accommodate a digester volume expansion event if properly configured.

Digested sludge storage tank mixing will be provided to keep solids in suspension and digested sludge storage will be connected to the low-pressure digester gas management system. Minimum total digested sludge storage requirements are shown in Table 7.5-4 to provide 3 days of storage.

Table 7.5-4: Digested Sludge Minimum Storage Requirement (3 days' storage)

Loading Condition	2025	2045	2060
Maximum month	742	1,101	1,182
Average annual	550	816	876

a. Storage requirements are shown in 1,000 gallons.

Digested sludge storage configuration should consider redundancy in order to maintain storage during tank cleaning and maintenance. Two options are proposed for consideration and incorporation into the approved project requirements.

- Construction of 2 dedicated digested sludge storage tanks – Storage tank diameter would match digester diameter with sidewall height adequate to provide a total combined storage of 3 days' maximum month digested sludge production. When additional digestion capacity is required, storage tank sidewall height could be raised to convert storage tank(s) to digestion service and new digested sludge storage could be constructed.

- Construction of 1 dedicated digested sludge storage tank – Storage tank construction would match digester construction to provide a digester volume of storage, which exceeds the minimum digested sludge storage requirement. An adjacent digester would be configured to serve as back-up digested sludge storage during cleaning and maintenance of the digested sludge storage tank. When additional digestion capacity is required, the digested sludge storage tank could be converted and new digested sludge storage could be constructed.

7.5.5.3 Dewatering System Performance Requirements

The performance requirements shown in Table 7.5-5 will be used for the dewatering technology evaluation only. These design performance requirements will be refined based on IEUA objectives and related process selections during detailed design. Maximum month digested sludge was selected for the design basis with the understanding that 3 days of upstream digested sludge storage will be provided, the operating schedule may be extended slightly during peak digested sludge production and a full standby unit will be provided.

Table 7.5-5: Dewatering System Performance Requirements

Performance Requirement	Value
Dewatering system solids processing capacity[a], dry lb TS/hour	14,735
Dewatering system hydraulic processing capacity[a], gpm	1,070
Desired minimum cake solids, %TS	24
Desired minimum solids capture efficiency, %	95

a. Based on maximum month projection for 2045 and 8 hours/day, 5 day/week operating schedule.

7.5.5.4 IEUA Dewatering Technology Preferences

The IEUA defined several preferences for the dewatering technology, as follows:

- Minimum 95% solids capture favoring capability for higher solids capture. This is important to avoid recycling solids back through the plant and the associated costs and potential risks to secondary process performance and stability.
- Strong record of municipal installations of the same equipment model or similar in North America.
- Operator familiarity with equipment.

- Equipment repair downtime must be low. Manufacturer services facilities must be able to respond quickly and spare primary equipment components should be stocked at the facility or quickly available through a manufacturer exchange program.
- Capable of fully automatic operation with limited operator observation.
- Preference towards fewer dewatering units to limit maintenance requirements and complexity.
- Low equipment repair/component replacement frequency.
- Low daily maintenance and housekeeping requirement.
- Low operator exposure to odors and contact with biosolids.
- Low wash water requirements. High wash water flows would have negative impacts on the overall secondary treatment process; a criterion that is incompatible with process treatment objectives.

7.5.5.5 Alternatives Performance and Equipment Data

The performance and equipment data summarized in Table 7.5-6 was used as the basis for developing the dewatering technology BCE. It should be noted that the BFP and Screw Press do not meet the desired performance parameters. This is not considered a fatal flaw and the impacts of lesser performance will be evaluated as cost impact in the BCE.

Table 7.5-6: Dewatering Equipment Performance and Equipment Data

Parameter	Centrifuge	Belt Filter Press	Screw Press
Operation Schedule	8 hour/day, 5 day/week	8 hour/day, 5 day/week	24 hour/day, 5 day/week
Number of units for year 2045, duty + standby	5+1	8+1	3+1
Unit Size	30-in bowl	2 meter	Dual 1,250-mm screws
Maximum Solids loading rate, lb/hr	3,500	2,000	2,000
Maximum Hydraulic loading rate, gpm	300	200	200
Cake solids concentration, %TS	24	18	20
Solids capture rate, %	95	95	90
Polymer dose, active lbs APS/dry ton solids	35	15	25
Washwater requirement, gpd per unit	5,000	60,000	17,000
Connected Power, hp per unit	250	20	15

7.5.5.6 Subjective Equipment Considerations

Subjective considerations for the three dewatering technology alternatives were presented for consideration as part of the selection process and are provided below.

<u>Centrifuge</u>

Pros:

- Typically provides highest cake solids and solids capture of considered alternatives

- Enclosed process minimizes odors, room humidity, and housekeeping
- Moderate operator attention requirements (highly automated)
- High installed capacity to building area ratio
- Operator familiarity

Cons:

- Relatively high energy requirement
- Equipment vibration may require building structural additions
- Relatively high noise level
- Relatively high polymer use
- High rotational speed (> 2,500 revolutions per minute [rpm]) → increased wear and maintenance particularly with high grit

Belt Filter Press

Pros:

- Relatively simple operation
- Relatively low energy requirement
- Relatively low polymer use
- High cake solids relative to alternatives when coupled with thermal hydrolysis

Cons:

- Relatively high housekeeping requirement
- Higher odor control flow requirement relative to other alternatives
- Higher wash water requirement relative to other alternatives and may require booster pumps
- Relatively high room humidity results in accelerated building wear
- Increased risk of sludge contact
- Higher potential operator health concerns
- Manual machine adjustment/optimization
- Increased safety risk due to exposed machine parts
- Lower cake solids concentration relative to other considered alternatives

Screw Press

Pros:

- Slow operational speed results in less wear and maintenance
- Relatively low polymer use
- Relatively low energy requirement
- Enclosed process minimizes odors, room humidity, and housekeeping
- Low operator attention requirements (highly automated)

Cons:

- Fewer municipal installations relative to centrifuges and BFPs
- Low hydraulic flow capacity relative to alternatives
- Lower solids capture than other considered alternatives

7.5.5.7 Redundancy Discussion

In order to provide redundancy for dewatering operations to maintain required capacity during extended maintenance events, one full standby dewatering unit along with all ancillary equipment will be provided. Supporting systems such as polymer, wash/spray water, conveyance and electrical will be designed to allow for operation of all dewatering units (including standby) to operate simultaneously in order to provide maximum operational flexibility in the event that plant operators decided to temporarily operate at a higher dewatering system throughput than the design basis.

A minimum of 3 days of upstream digested sludge storage is provided to eliminate the need for dewatering shifts during three day weekends and also to provide additional operational flexibility for the dewatering system.

7.5.5.8 Alternatives Sizing Results

Dewatering equipment for the three alternatives was selected and the number of units required was determined based on the design information presented in this chapter. Although the recommended number of units for 2045, digested sludge production is indicated in Table 7.5-6, fractional units are shown below to facilitate project phasing discussions. Results for centrifuge sizing are presented in Table 7.5-7 based on the IEUA's preliminary selection of this dewatering technology.

Table 7.5-7: Dewatering Centrifuge Equipment Number of Operating (Duty) Units

Parameter	2025	2045	2060
Maximum month loading	2.8	4.2	4.5
Average annual loading	2.1	3.2	3.4

7.5.5.9 Facility Layout

A centrifuge-based facility preliminary layout is provided in Chapter 2 of this volume. Dewatering facility preferences were summarized by IEUA staff and carefully considered during development of this layout.

7.5.6 Dewatering Equipment Business Case Evaluation

This section presents the evaluation of dewatering equipment, including a summary of BCE results.

7.5.6.1 Evaluation Process

In addition to the screening step described previously, inputs and assumptions for evaluation of dewatering equipment were developed collaboratively with IEUA staff. The IEUA standard BCE template was used to develop comparative NPVs for dewatering facilities constructed in 2022 and operating through 2045.

7.5.6.2 Business Case Evaluation Results and Analysis

Results of the BCE are provided below in Table 7.5-8. All costs are in 2016 dollars. The full BCE spreadsheets are presented in Exhibit I of this Volume.

Updated Table 7.5-8: Results of the Business Case Evaluation

Alternative	Capital (1)	O&M (2)	R & R (2)	NPV
Centrifuge	$64,300,000	$104,419,000	$2,060,000	$174,860,000
Belt Filter Press	$72,000,000	$84,277,000	$2,116,000	$192,880,000
Screw Press	$57,500,000	$113,039,000	$3,488,000	$177,640,000

(5) Capital costs shown are un-escalated 2016 dollars
(6) O&M and R&R costs shown are escalated and discounted back to 2016 dollars.

Centrifuge dewatering has the lowest O&M and R&R costs and results in the overall lowest NPV. Screw press dewatering has the lowest capital, the highest R&R costs, and results in the marginally higher NVP when compared to the centrifuge dewatering alternative. Given the accuracy of the BCE at this level of design, centrifuge and screw press dewatering alternatives can be considered equivalent.

A sensitivity analysis was performed and determined that BCE results are not sensitive to typical variables across dewatering technology alternatives. Significant changes to power, polymer, and dewatered sludge disposal costs will not result in a significant change to the BCE outcome.

The primary BCE influencers were:

- Dewatered sludge disposal cost of $53/wet ton at composting facility plus hauling costs
- Higher capacity per unit of centrifuges results in fewer units required and lower space requirement
- Higher capacity-to-space requirement of centrifuges results in lower space requirement

7.5.7 Agency Decisions and Preferences for the Approved Project Requirements

The purpose of this section is to document recent IEUA direction/preferences provided during the BCE workshop on August 11, 2016. These preferences will not affect the comparative decision-making process provided through the BCE analysis. The impact on the dewatering equipment size, number, layout, and cost will be evaluated at the next detailed design phase of the project.

Major items to be integrated into the final Approved Project Requirements include:

- Determination of FOG or FW feed to digesters
- Evaluation of digester facility phasing to manage capital expenditures
- Site planning for potential addition of future FW, FOG, and SHF digestate
- Evaluation of digested sludge storage tanks as one larger tank that could be used as sludge storage or serve as a future digester
- Dewatering building layout refinements, such as moving the polymer system to the second floor, to accommodate Agency preferences
- Integration of a long term maintenance agreement into the procurement process
- Consideration of alternative cake conveyance systems

7.5.8 Recommendations

Based on the BCE results and further discussion of non-cost-related considerations with the Agency, it is recommended to make a selection between centrifuge and screw press dewatering alternatives. A few potential considerations are outlined below.

Centrifuges:

- IEUA staff is familiar with centrifuge equipment
- Centrifuges are sized based on 8-hour operation; however, they can operate longer hours in a given day if required during higher loading periods
- Relatively high noise level for centrifuges

Screw presses:

- Using a 24-hour-per-day operating schedule may require more upstream digested sludge storage, more dewatering units, or more dewatering hours during periods of high solids production
- Since units are sized for 24-hour operation, there is less flexibility to "catch up" on sludge inventories during higher loading periods
- Fewer municipal installations relative to centrifuges
- Lower solids capture than centrifuge
- Potential struvite buildup may degrade performance of the screws overtime and will require additional maintenance

7.6 EVALUATION OF RP-5 GAS STORAGE AND WASTE GAS FLARES

7.6.1 Introduction

This introductory section presents project background as well as and understanding and approach for digester gas storage and waste gas flare alternatives.

Biogas generated by the anaerobic digestion process at RP-5 will be captured, conveyed, and used beneficially for energy recovery and reduction of greenhouse gas (GHG) emissions. The digester gas management system is composed of gas piping, controls, storage, conditioning, utilization, and safety equipment. This section focuses on the gas storage and waste gas flare components of the gas management system.

Digester gas production is variable depending on changes in organic loading and operating conditions. The role of gas storage is to help facilitate smooth operation of gas system equipment and to maximize conversion of digester gas to energy. When digester gas production exceeds what can be used or stored, or if utilization equipment is out of service, waste gas flares are used to combust excess gas to reduce GHG emissions and meet air permit requirements.

7.6.1.1 Digester Gas Storage

This section includes a comparison of gas storage technologies, screening of candidate options, and capital cost comparison for a range of gas storage volumes. Design of biogas storage is integral to the evaluation of gas utilization alternatives. Therefore, the design gas storage volume and complete life-cycle cost considerations for gas storage are to be incorporated into the BCE for the digester gas utilization BCE (Chapter 9). This evaluation was conducted before the gas utilization evaluation was completed. Therefore, the exact volume of gas storage needed to optimize gas utilization equipment operation was not available. A range of gas storage volumes was considered for the comparison. It is assumed this approach will be sufficient for preliminary recommendations on gas storage volumes and technology selection.

7.6.1.2 Waste Gas Flares

Waste gas flares are required ancillary anaerobic digestion equipment used for safely wasting excess digester gas and to meet air permitting regulations. The type of flare required is dependent on the selected anaerobic digestion process configuration, which impacts the characteristics of the digester gas. This section includes a comparison of flare technologies that cover all of the digester process configuration alternatives being considered in Section 7.4: conventional MAD, 2-Phase, and THP. Because the type of flare(s) required will depend on the selected digestion alternative, the life-cycle costs of the flares are incorporated into the digestion BCE (Section 7.4).

7.6.2 Biogas Characteristics and Production

Table 7.6-1 contains the biogas system basis of design criteria. This is based on the plant solids, FW, and FOG loadings established in the solids mass balance. The design capacity for waste gas assumes all of the gas produced has to be sent to the flares. A peaking factor of 1.5 is applied to the peak day gas production to account for instantaneous peaks.

Table 7.6-1: Biogas System Basis of Design

Parameter	Unit	Value
Biogas Production (average day, 2045)	scfm	950
Biogas Production (peak day, 2045)	scfm	1,400
Gas Peaking Factor (waste gas)	–	1.5
Max Design Biogas to Flares (2045)	scfm	2,100

7.6.3 Gas Storage Purpose and Criteria

7.6.3.1 Introduction

Biogas storage is one component of the digester gas management system. The purpose of gas storage is to help facilitate smooth operation of gas utilization equipment and to maximize conversion of digester gas to energy. Digester gas production is variable, but utilization equipment operates best with a steady supply of gas. Storage effectively dampens the variation in the digester gas production rate. Gas storage can also provide a control signal from which the entire gas handling and utilization systems can be operated.

As an alternative to (or in addition to) gas storage, variations in digester gas production can be accounted for by blending with natural gas to achieve a steady supply to the gas utilization equipment.

7.6.3.2 Design Criteria for Biogas Storage

The design criteria for sizing biogas storage are set by the functional requirements of the gas utilization equipment. These criteria include typical diurnal gas production values, target percentage of biogas captured for utilization (not flared), gas system operating pressure, and the operating philosophy/method for controlling the gas utilization equipment. These criteria are still under development and will be covered in the digester gas utilization and BCE in Chapter 9. The technology evaluation in this chapter is based on typical gas system operating pressures. A range of storage volumes are considered.

7.6.4 Biogas Storage Technologies

7.6.4.1 Flexible Membrane

Dual-membrane gas holding systems have been used in the industry for nearly 20 years. These systems hold biogas at low pressures, between 6 inches water column (inches w.c.) to 16 inches w.c. The dual-membrane systems consist of an outer membrane that maintains a consistent dome shape, while the inner membrane moves depending on gas storage requirements. The space between the inner and outer membranes is kept pressurized using small, ambient air blowers in conjunction with pressure-release valves.

Dual-membrane gas holders can be installed on top of a digester tank or directly on the ground. A ground-mounted gas holder has a third ground membrane that provides a gas-tight connection along the bottom of the holder. The ground membrane is typically positioned on top of a concrete slab or in some installations directly on compacted fill.

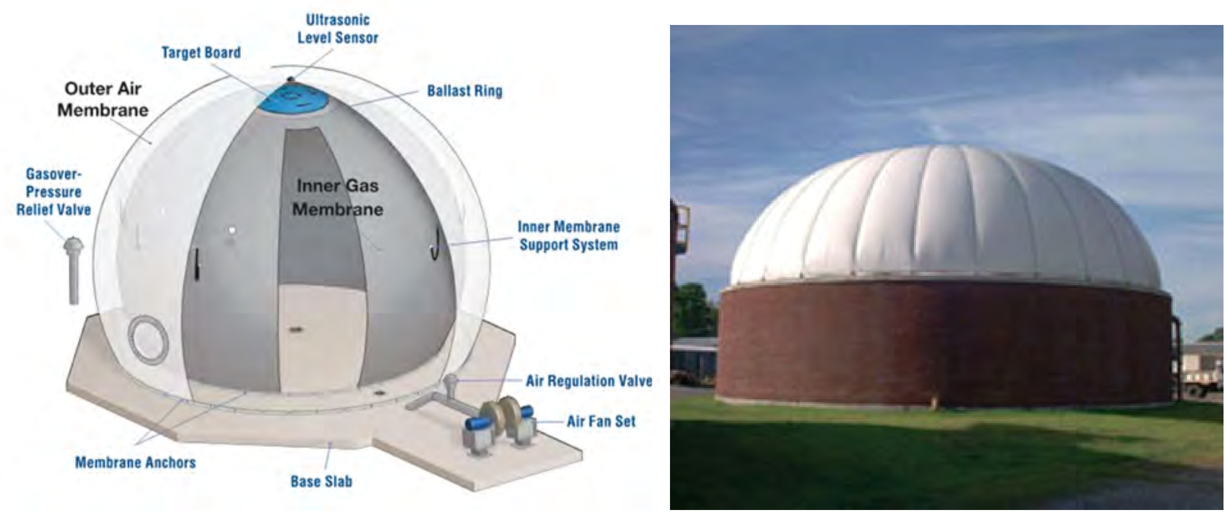


Figure 7.6-1: Flexible-Membrane Gas Storage Configurations

Left – Ground-Mounted Dual Membrane Storage Schematic / Right – Photo of Digester Cover Mounted Membrane Storage

Membranes installed on top of digester tanks are at an increased risk of failure due to rapid volume expansion or foaming events which can plug gas piping and lead to over-pressurizing the membrane. Installing the membrane on a separate slab mitigates this risk by completely decoupling the gas storage from the operation of the digestion system. Alternatively, the membrane can be installed on a digested sludge storage tank. These tanks store biosolids that have already been stabilized by the digestion process and are therefore much less likely to experience a foaming event that could plug gas piping.

7.6.4.2 Floating Gas-Holder Digester Cover

The floating gasholder cover is ballasted to balance the buoyant forces of the digester fluid, the cover weight, and the gas dome pressure. This cover is similar to the standard floating cover with the addition of an extended skirt to permit digester gas storage within the void created by the added skirt length.

This type of system has several major disadvantages: the gas/liquid interface is across the entire surface area of the digester; it has a high internal corrosion potential; it has a high capital cost relative to other cover types; and the volume of space to be purged to take the digester out of service is higher than that of other systems. The taller dome makes safe sampling of the digester contents and maintenance of the pressure/vacuum relief devices difficult. Gasholder covers do not allow use of roof-mounted mechanical draft tube mixers. These covers can also require additional wind load protection.

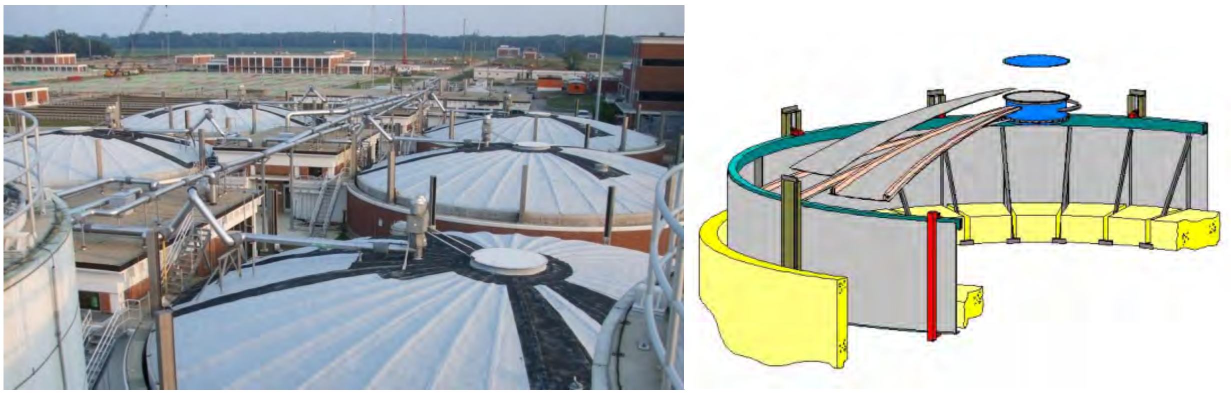


Figure 7.6-2: Digester Gas-Holder Covers

Left – Photo of Floating Gas-Holder Covers / Right – Cutaway Schematic of Floating Gas-Holder Cover

7.6.4.3 Dry-Seal Gasholder

The dry-seal "Wiggins" type gasholder uses an internal membrane to contain the stored biogas. The main elements of this gas holder are the foundation, the main tank, the piston and the sealing membrane. The gas enters the holder from beneath the piston which floats on the internal gas pressure. The gas holder piston moves up and down inside the tank as gas enters and exits. The weight of the piston produces the pressure at which the gas holder is designed to operate. A mechanical counterbalance system of weights and pulleys works to ensure that the pistons moments are kept in equilibrium. The level of the piston/membrane provides a reliable control signal for management of the digester gas system. The maximum operating pressure for a dry-seal gasholder is typically limited to 14 inches w.c.

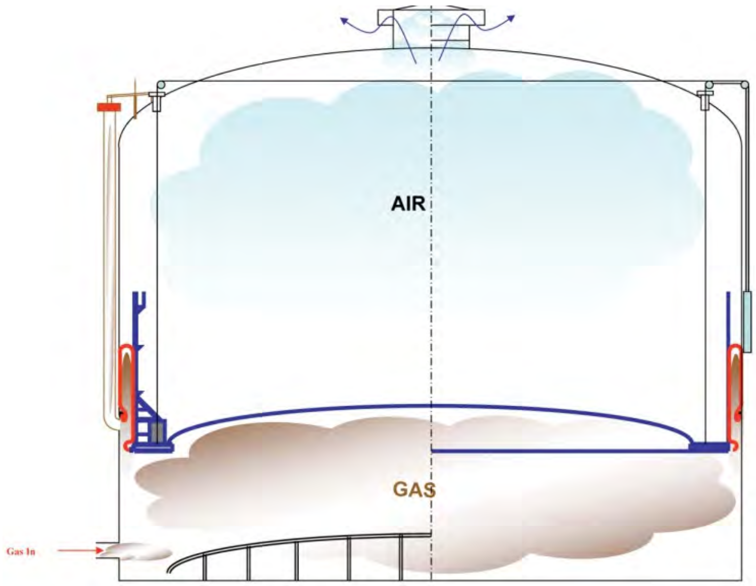


Figure 7.6-3: Dry-Seal Gasholder

7.6.4.4 Wet-Seal Gasholder

Wet-seal digester gas holders consist of an outer shell, inner piston, water seal, and stabilizing system. It operates on the same principle as a floating gas-holder digester cover; as gas enters/leaves the headspace of the tank, the ballasted cover rises and falls to accommodate the change in gas volume while maintaining a constant gas pressure. Wet-seal gasholders are generally larger than a dry seal with equivalent active gas storage because of the volume of water in the tank. The wet-seal gasholders have the ability to operate at slightly higher pressures than the dry-seal gasholders.

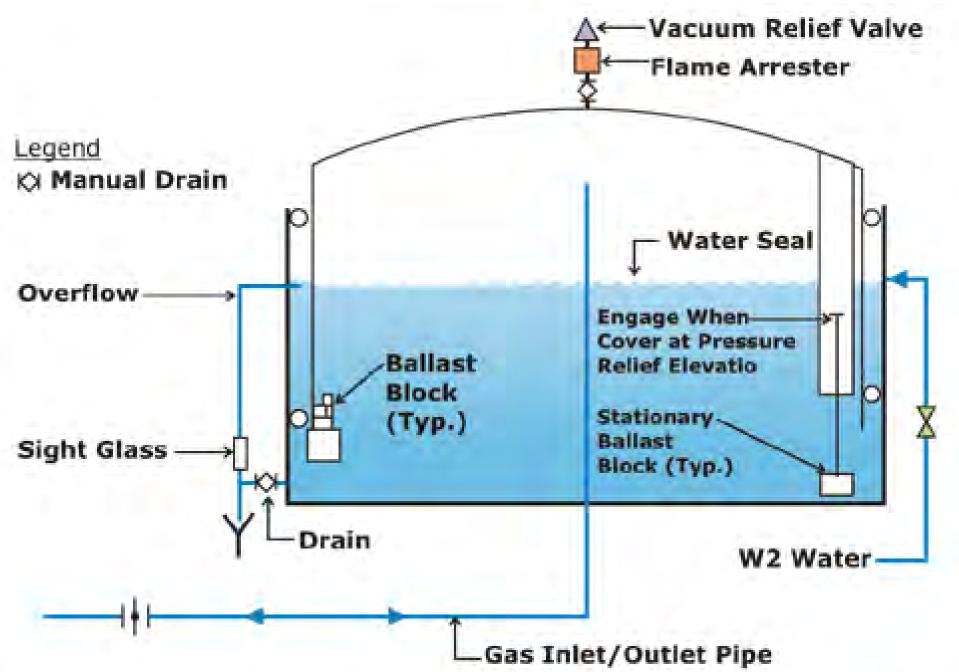


Figure 7.6-4: Wet-Seal Gasholder

7.6.4.5 High Pressure Gas Storage

High-pressure gas storage consists of a steel structure designed for storing high-pressure gas downstream of blowers to provide buffering to downstream gas utilization equipment. Typically, these are either spheres or cylindrical tanks. A standard design is constructed with ¼-in-thick ASTM SA516 A36 steel material, which is suitable for operating pressures at up to 75 pounds per square inch gage (psig). Digester gas spheres can be designed for higher pressures at higher costs.

Storing at high pressure does nothing to address the variability in digester gas production upstream of gas blowers. Other disadvantages of high-pressure gas storage include corrosion concerns, higher energy demand, and safety issues with pressurized gas.

Figure 7.6-5: High-Pressure Gas Storage

Left – Photo of Storage Sphere / Right – Photo of Horizontal Cylinder Storage Tanks

7.6.5 Gas Storage Alternatives Screening

7.6.5.1 Introduction

The technologies described above were evaluated at a high level and given quantitative scores and weighting factors in order to screen the alternatives for more detailed analysis.

7.6.5.2 Screening Criteria

Screening criteria for digester gas storage alternatives included four pass/fail criteria and five quantitative criteria and are included in Table 7.6-2.

Table 7.6-2: Gas Storage Screening Criteria

Criteria	Type	Description
Supports Treatment and End-Use Objectives	Pass/Fail	Contributes to the objective of providing an adequately steady supply of gas for beneficial use.
Meets Desired Performance	Pass/Fail	Proven ability to reliably store biogas within the digester gas pressure operating range (for low pressure) or compressed at up to 75 psig (for high pressure).
Provides Proven Technology	Pass/Fail	Technology has been proven reliable for more than 10 years in plants of comparable size - not emerging, research, or pilot technologies.
Provides Acceptable Complexity	Pass/Fail	Technology does not require extraordinary expertise or resources unreasonably beyond traditional operations and maintenance resources currently employed.
Capital Cost	Quantitative (1 – 5)	Relative capital cost of alternatives. 5 is least expensive and 1 is most expensive.
O&M Requirements	Quantitative (1 – 5)	Ease of O&M, cost of O&M, frequency of replacement/maintenance. 5 has lowest O&M impact/cost, 1 has the highest.
Footprint	Quantitative (1 – 5)	Impact on site layout. 5 is lowest impact and 1 is greatest impact.
Safety Impacts	Quantitative (1 – 5)	Impacts to safety including safe access to equipment for O&M, reliability of gas seals, pressurized gas, etc. 5 has the lowest impact to safety, 1 has the highest.
Process Control	Quantitative (1 – 5)	Ability to produce a reliable control signal for digester gas management. 5 has the most reliable/robust control, 1 has the least.

7.6.5.3 Screening Results

The results for the gas storage screening are included in Table 7.6-3.

Table 7.6-3: Gas Storage Screening Results

Gas Storage Alternatives	Weight	Membrane (Digester)	Membrane (Ground)	Gas-holder Cover	Dry Seal	Wet Seal	High Pressure
Supports End-Use Objectives	Pass/Fail	YES	YES	YES	YES	YES	YES
Meets Required Performance	Pass/Fail	YES	YES	YES	YES	YES	YES
Proven Technology	Pass/Fail	YES	YES	YES	YES	YES	YES
Acceptable Complexity	Pass/Fail	YES	YES	YES	YES	YES	YES
Relative Capital Cost	25%	5	5	3	2	1	2
O&M Requirements	25%	2	2	2	4	4	1
Footprint	15%	4	2	4	2	2	3
Safety Impacts	20%	1	3	2	4	4	2
Process Control	15%	2	2	4	5	5	3
Weighted Average		**2.9**	**3.0**	**2.9**	**3.4**	**3.1**	**2.1**

7.6.5.4 Screening Recommendation

Based on the scores of the screening criteria for the digester gas storage alternatives, we recommend comparing the dry-seal gasholder (which received the highest score) with the slab-mounted flexible membrane (the lowest-cost option). The digester cover options (membrane and floating gasholder cover) are not compatible with the type of covers being considered for the digestion system, and the wet-seal gasholder is more expensive than the dry seal for the same amount of storage volume. The flexible membrane cover is also an option if installed on digested sludge storage tanks, as foaming/volume expansion impacts are of less concern.

7.6.6 Gas Storage Alternatives Comparisons

7.6.6.1 Capital Costs

Capital costs for four different storage volumes are presented in Table 7.6-4.

Table 7.6-4: Gas Storage Capital Cost Comparison

Volume of Gas Storage (ft^3)	Dry-Seal Gasholder	Slab-Mounted Membrane
30,000	$2,800,000	–
50,000	$3,800,000	$1,000,000
90,000	$5,300,000	$1,300,000
250,000	–	$2,000,000

7.6.6.2 Operating and Maintenance Considerations

Operation and maintenance considerations for the dry-seal gasholder and membrane gas storage options are presented in Table 7.6-5.

Table 7.6-5: Gas Storage O&M Considerations Comparison

O&M Consideration	Dry-Seal Gasholder	Membrane (slab-mounted)
Operation – pressure control	Provides inherent constant pressure through ballast of internal piston	Blowers/controls used to maintain a pressure setpoint
Operation – control signal for gas management	Provides reliable/simple control signal via gasholder level	Membrane manufacturers use ultrasonic, infrared, or mechanical gauge to calculate estimated volume of stored gas
Energy	No power requirements	Blowers required to pressurize space between membranes
Maintenance	Inspect once/5 yrs – requires nitrogen purge Recoat or repair seals as needed	Inspect annually Blower maintenance Membrane repairs Periodic purging of methane between membranes
Replacement Costs	Recoating of tank and repairs/replacement of internal seal Long life for steel tank	Replacement cost is usually almost equal to the cost of a new installation Lifespan 10 years to 15 years (failures have occurred sooner)
Safety	Robust steel tank	Membrane failure possible

O&M Consideration	Dry-Seal Gasholder	Membrane (slab-mounted)
	Headspace above piston is atmospheric conditions Gas monitor for leak detection	Methane accumulation between membranes requires purge to prevent explosive conditions

7.6.7 Gas Storage Summary

7.6.7.1 Conclusions

The comparison of gas storage alternatives suggests the following:

- Dry-seal gasholders received the highest score of the gas storage technologies evaluated on a screening-level basis.
- Dry-seal gasholders were compared to flexible membranes on capital cost and O&M considerations:
  - Flexible membrane gas storage has the lowest capital cost on a $/ft^3 basis.
  - Dry-seal gasholders offer superior O&M characteristics over membranes, including constant gas pressure, reliable and simple control of the gas system using gasholder level, and no power requirements for blowers.
- This evaluation was conducted before the gas utilization evaluation was completed. Thus, the exact volume of gas storage needed for gas utilization equipment operation was not available. A range of gas storage volumes was considered for the comparison of dry-seal gasholder and flexible-membrane storage options. It is assumed this approach will be sufficient for preliminary recommendations on gas storage volumes and technology selection.

7.6.7.2 Gas Storage Recommendations

Based on the evaluation provided, the following preliminary recommendations are provided:

- At RP-5, installation of one small dry-seal gasholder for low pressure gas storage is recommended to set a constant gas pressure on the gas system and to provide a reliable control signal (gasholder level) for gas system operation. This tank will have approximately 30,000 ft^3 of gas storage and a 35-ft diameter.
- At RP-5, installation of one large slab-mounted flexible membrane is recommended for additional gas storage volume required beyond what is provided by the dry-seal gasholder. The dry-seal gasholder is more expensive on a $/ft^3 basis, but can provide better O&M characteristics even with a relatively small volume. Additional gas storage volume will be provided with the more cost-effective flexible membrane. Preliminary recommendation is for approximately 90,000-ft^3 membrane with an outside base diameter of 60 ft.
- The total capital cost in 2016 dollars for these gas storage recommendations at RP-5 is $4.1 million.
- Once the gas utilization evaluation has been completed, it is recommended that the volumes of gas storage are revisited and optimized.

7.6.8 Waste Gas Flare Purpose and Criteria

Waste gas flares are required ancillary anaerobic digestion equipment used for safety wasting excess digester gas and to meet air permitting regulations. The type of flare required is dependent on the selected anaerobic digestion process configuration, which impacts the characteristics of the digester gas. This section includes a comparison of flare technologies that cover all of the digester process configuration alternatives being considered: conventional MAD, 2-Phase, and THP. Because the type of flare(s) required will depend on the selected digestion alternative, the life-cycle costs of the flares are incorporated into the digestion BCE (Section 7.4).

The design criteria for the waste gas flares are presented in Table 7.6-6.

Table 7.6-6: Waste Gas Flare Design Criteria

Parameter	Unit	Value
Biogas Production (average day, 2045)	scfm	950
Biogas Production (peak day, 2045)	scfm	1,400
Gas Peaking Factor (waste gas)	–	1.5
Max Design Biogas to Flares (2045)	scfm	2,100
Flare Basis of Design Model	–	Varec 244E (Enclosed Type)
Flare Size (gas inlet connection)	in	12
Number of Flares	–	2
Flare Capacity, each (11-in w.c. inlet pressure)	scfm	1,050
Destruction Efficiency	%	> 99.0
Max Design Acid-Gas to Thermal Oxidizer (2045) (for 2-Phase option only)	scfm	110
Number of Acid-Gas Thermal Oxidizers (for 2-Phase option only)	–	1
H_2S Concentration at Flare/Thermal Oxidizer	ppm	40

The flares must be sized to handle the peak gas production when all utilization equipment is out of service, but also to handle small amounts of gas when production exceeds utilization and storage capacities (aka: “trim”). For this reason, two flares are needed to turn down for the lower trim gas flows while still meeting the maximum case capacity.

The 40 ppm H_2S concentration to the flares is a universal requirement that will be achieved by an H_2S removal system for each process configuration/flare technology discussed.

7.6.9 Waste Gas Flare Technologies

7.6.9.1 Candlestick

Candlestick flares are very common at WWTPs. They are an older technology and are the least efficient combustion technology among flares and thermal oxidizers. See Figure 7.6-6 for a photo of candlestick flares. Of all options they have the greatest loss of unburned digester gas (up to 10% in high wind conditions) and contribute a large GHG emission.

Figure 7.6-6: Candlestick Waste Gas Flares

7.6.9.2 Enclosed

Enclosed flares are becoming more prevalent at WWTPs. Enclosed flares have no visible flame and have very low emissions relative to open/candlestick flares. Because these flares are enclosed they are protected from wind and maintain a stable flame. Combustion efficiencies are generally 98% to 99%. See Figure 7.6-7 for photos of enclosed flares.

Figure 7.6-7: Enclosed Waste Gas Burners

7.6.9.3 Thermal Oxidizer

Thermal oxidizers are the most complex option for combusting a waste gas stream. These are typically only considered at WWTPs for extremely low quality gas streams with high volatile organic compounds (VOCs) and hazardous air pollutants (HAPs). Thermal oxidizers maintain a high temperature in a designed combustion chamber. Some configurations of thermal oxidizers include heat recovery systems to increase the efficiency of the efficiency of the system and reduce auxiliary fuel consumption. Thermal oxidizers may also require a combustion air blower to get enough oxygen into the combustion reactor.

Thermal oxidizers will only be considered as a feasible option for the 2-Phase digestion process alternative, which generates a low British thermal unit (BTU), high H_2S waste gas from the first-stage acid reactors.

7.6.10 Waste Gas Flare Alternatives Screening

Candlestick flares are not a modern technology and may have issues meeting California Air Quality Standards/permit requirements in the South Coast Air Quality Management District (SCAQMD). It is sensible to screen out candlestick flares from further evaluation given industry trends and to mitigate the risk of permitting/compliance issues.

7.6.11 Waste Gas Flare Alternatives Comparison

The type/configuration of the waste gas flares is dependent on the selected digestion process alternative. For this reason, the flare configurations are assigned to specific digester process options as shown in Table 7.6-7.

Table 7.6-7: Waste Gas Flare Configurations for Digestion Alternatives

Flare Configuration	MAD or THP	2-Phase
2 Enclosed Flares	YES	YES (if acid and gas phase reactor gas streams are combined or an assist gas is used)
1 Thermal Oxidizer + 2 Enclosed Flares	NO	YES

Two enclosed flares will be the basis of design for the MAD and THP digestion alternatives (Chapter 8). This will require a single H_2S removal system for the digester gas with a target outlet concentration of 40 ppm. The basis for this system will be iron sponge, which is what is used at other IEUA digestion facilities.

For the 2-Phase alternative there are three possible options:

1. Two enclosed flares – combine the acid-phase and second-stage gas streams so that they can be combusted together in an enclosed flare when needed.
2. Two enclosed flares – designate one enclosed flare for the acid phase waste gas and use an assist gas to allow continuous combustion of the low-BTU acid gas.
3. One thermal oxidizer and two enclosed flares – the thermal oxidizer will be designated for the acid phase waste gas. A combustion air blower will be required.

Each of the options for the 2-Phase alternative will require an H_2S removal system. For the first alternative where the gases are combined, a single iron sponge system is required. For the second and third alternatives, two separate H_2S systems will be needed – one for the acid-phase gas and one for the second-stage gas. These systems will be both be based on iron sponge, which are used at other IEUA digestion facilities.

The O&M considerations for each of these alternatives are summarized in Table 7.6-8.

Table 7.6-8: Two-Phase Waste Gas O&M Considerations

O&M Consideration	Two Enclosed Flares	Two Enclosed Flares (one with assist gas)	One Thermal Oxidizer and Two Enclosed Flares
Complexity	Low – standard enclosed flare operation with no assist gas needed	Low – digester or natural gas needed to assist in combustion of acid-phase gas	High – more mechanical complexity. Combustion air blower and heat recovery equipment
Maintenance	Few components requiring maintenance	Few components requiring maintenance	More maintenance needed for combustion blower and additional H_2S removal system.
Operating Cost	Low – low maintenance, no electrical loads, no assist gas	High – natural gas purchase or use of gas-phase gas to combust the acid-phase in an enclosed flare	Medium – low/no assist gas needed, but electrical load for combustion air blower and increased maintenance costs.
Other Considerations	Feasibility concerns with achieving blend of acid/gas phase. Peaks of high H_2S gas from acid-phase may impact gas blowers and H_2S removal equipment.	Separate combustion of acid-phase gas improves quality of second-stage gas for conditioning and utilization.	Separate combustion of acid-phase gas improves quality of second-stage gas for conditioning and utilization.

7.6.12 Waste Gas Flare Preliminary Summary

For the purposes of evaluating the digestion alternatives (Chapter 8), the THP and MAD alternatives will assume two enclosed flares, and the 2-Phase alternative will assume two enclosed flares with a thermal oxidizer to handle the acid-phase gas. The capital cost of these flare configurations are provided in Table 7.6-9.

Table 7.6-9: Waste Gas Flare Capital Costs

Two Enclosed Flares (MAD and THP)	Two Enclosed Flares + Thermal Oxidizer (2-Phase)
\$2,000,000	\$2,700,000

7.6.12.1 Waste Gas Flare Preliminary Conclusions

The comparison of waste gas flare alternatives suggests the following:

- Two enclosed flares are the basis of design for waste gas combustion. Open flares are not suitable for the permit requirements in the SCAQMD.
- The acid-gas produced in the 2-Phase digestion alternative can be handled with an additional thermal oxidizer, by combusting it in an enclosed flare with an assist gas, or by combining it with the second-stage gas system. The digestion evaluation assumes a thermal oxidizer will be provided in addition to the two enclosed flares.
- An H_2S treatment system is required to reduce concentrations to 40 ppm at the flares/thermal oxidizers. A single system will be required for MAD and THP digestion alternatives. Two separate systems will be needed if the acid-gas from the 2-Phase alternative is kept separated.

7.6.12.2 Waste Gas Flare Preliminary Recommendations

Based on the evaluation provided, the following preliminary recommendations are provided:

- At RP-5, installation of two enclosed flares to handle the digester gas is recommended. This will meet both the peak waste gas condition and trimming of small gas volumes that exceed the utilization and storage capacities. The capital cost in 2016 dollars for these flares is $2 million.

- If 2-Phase is the selected digestion alternative for RP-5, additional considerations are required for the acid-phase gas. Installation of an additional thermal oxidizer is the preliminary recommendation to flare the acid-phase gas, but the options discussed in Section 7.6.7.5 for handling this gas should be evaluated in greater detail during detailed design. The capital cost in 2016 dollars for the thermal oxidizer with the enclosed flares is $2.7 million.

- At RP-5, installation of H2S removal upstream of flares will be required to meet SCAQMD Title V air permit requirements. Iron sponge is suitable and is recommended based on IEUA's experience with the technology, but additional investigation will be required once the digestion alternative and handling of the acid-gas are decided upon.

7.6.13 Agency Decisions and Preferences for the Approved Project Requirements

The purpose of this section is to document recent IEUA direction/preferences provided during the BCE workshop on August 11, 2016, that are not included in this evaluation but deferred to the approved project. This evaluation would only be updated to address minor comments that would have the potential for affecting the technology selection. The impact on the gas storage and flare equipment size, number, layout, and cost will be evaluated at the next detailed design phase of the project.

Major items to be integrated into the final Approved Project Requirements include:

- Evaluation of safety impacts on location of high-voltage power lines in proximity to digester gas storage site location for the approved project

- Evaluation of iron sponge, carbon-based, and biological removal technologies to meet H_2S requirements for waste gas flares and gas utilization
- Selection of final gas utilization alternative and gas storage volume optimization as part of final sizing and configuration
- Evaluation of flexible-membrane gas storage mounted on top of a digested sludge storage tank instead of separate slab for conserving site layout
- Elimination of FOG or FW feed to digesters
- Digester phasing and appropriate gas system sizing to match phases
- Potential addition of food waste, FOG, and SHF digestate in the future
- Thermophilic and mesophilic digestion flexibility, including inclusion of equipment for thermophilic operation and the potential need for gas chilling and moisture removal with thermophilic operation

7.6.14 Subsequent Evaluation of Waste Gas Flares

Following the preliminary waste gas flare screening above, a more detailed evaluation of the available flaring options was performed. Additional data was gathered in regard to regulatory emissions requirements and gas production data was updated following subsequent meetings and workshops with the Client.

7.6.14.1 Regulatory Emissions Requirements

The RP-5 facility is under the jurisdiction of the SCAQMD, the air pollution control agency for the IEUA. Prior to construction, biogas elimination and the resulting emissions must be reviewed and approved by the SCAQMD.

With the expected quantity of biogas production of the RP-5 solids digestion method, the facility is defined as a “Major Source” according to Title V as adopted and modified by the SCAQMD from the EPA.

As a Major Source the waste gas process emissions will need to meet either the Best Available Control Technology (BACT) or the Lowest Achievable Emission Rate (LAER). BACT or LAER determination is on a case-by-case basis by the SCAQMD. For the purpose of this evaluation, it was determined that the flares at the RP-5 facility must meet LAER for criteria pollutants as defined below.

Table 7.6-10: Waste Gas Flare Emissions Requirements

Criteria Pollutant	Emission Factor (lb/MMBTU)	Emission Factor (ppm)
NOx	0.025	19
CO	0.06	75
VOC Destruction Efficiency	> 99%	N/A

Due to the stringent criteria pollutant limits of LAER, a standard enclosed flare will not meet emissions requirements. Ultra-low emissions enclosed flares were the next flaring technology evaluated against the expected emissions requirements and thermal oxidizers.

7.6.14.2 Description of Approved Waste Gas Flare Technology

Ultra-low emissions enclosed flares have a similar configuration to standard enclosed combustion flares in regard to the flaring section with an enclosed tower that promotes flame stability. Where the ultra-low emissions flare differs is the addition of specialized combustion air blowers and an extended fuel/air pre-mixing section upstream of the flare to ensure a consistent homogenous air/fuel mixture. These blowers bring in additional air that is blended with the biogas prior to combustion resulting in lower emissions of criteria pollutants.

Figure 7.6-8: Ultra-Low Emission Enclosed Gas Flare

Image courtesy of John Zink

7.6.14.3 Updated Design Criteria for Waste Gas Flares

Design criteria for flare type and sizing are set by calculated biogas production and regulatory emissions requirements. The flares are sized to handle the peak design gas production when all other utilization equipment is out of service, but also to handle small amounts of gas when production minimally exceeds utilization. For this reason, two independent flares, of differing sizes and capacities, are needed to turn down for the lower gas flows while still meeting the maximum case capacity.

Updated biogas design criteria for the waste gas flares are presented below in Table 7.6-11. Note that these criteria supersede the data in Table 7.6-6 and were refined from subsequent meetings and discussions with the Client.

Table 7.6-11 Updated Biogas Design Criteria

Parameter	Unit	Value
Biogas Production, average day (2045)	scfm	530
Biogas Production, peak day (2045)	scfm	965
Gas Peaking Factor (waste gas)	--	1.5
Design Biogas to Flares, maximum (2045)	scfm	1,450
Design Acid-Phase Gas, maximum (2045)	scfm	100
Treated Biogas H_2S Concentration to the Flares	ppmv	40
Methane Concentration in Thermophilic Gas	% mole	~60
Methane Concentration in Acid-Phase Gas	% mole	13-25

The 40-ppm H_2S concentration to the flares is a plant-wide air quality requirement that will be achieved by an H_2S removal system for each process alternative discussed.

7.6.15 Updated Description of Waste Gas Flare Alternatives

7.6.15.1 Introduction

A further analysis of waste gas flare alternatives given updated criteria has ultimately four alternative methods for the burning of waste gas. These various configurations included: H_2S removal, gas pressurization, and the waste gas burning technology. The evaluated alternatives are as follows.

7.6.15.2 Alternative 1A: Combined Acid-Phase and Digester Gas Streams with Duplex Treatment

This alternative mixes or combines both gas streams prior to H_2S removal and flaring. Under normal operating conditions, the acid-phase gas will be flared as needed with a small amount of digester gas as a supplement to meet the flare's stable fuel combustion requirements.

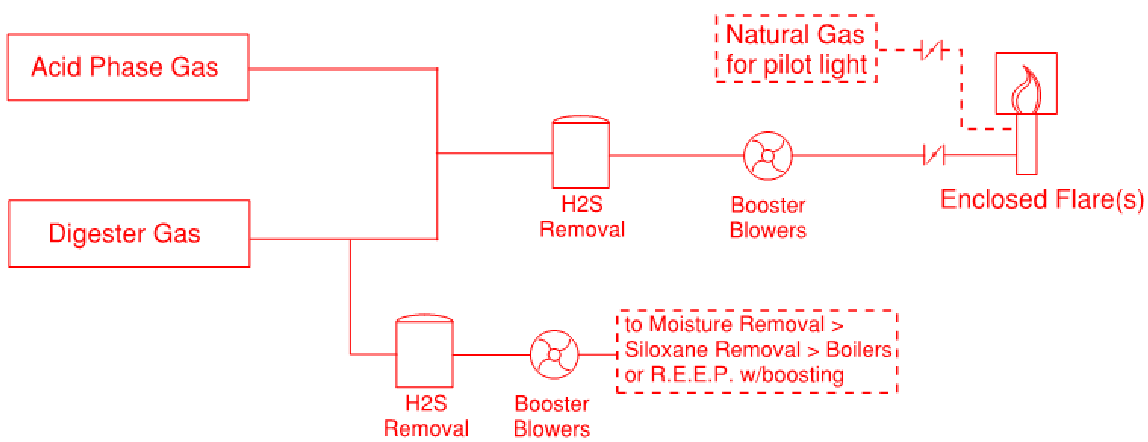


Figure 7.6-9: Schematic of Waste Gas Flare Alternative 1A

7.6.15.3 Alternative 1B: Combined Acid-Phase and Digester Gas Streams with Merged Treatment

This is similar to the above except that the gas streams mix prior to a H_2S removal system. Flares only operate if there are excess gas flows or if gas utilization is out of service. Under normal operating conditions, the blended gas, containing acid-phase, and digester gas will be beneficially utilized.

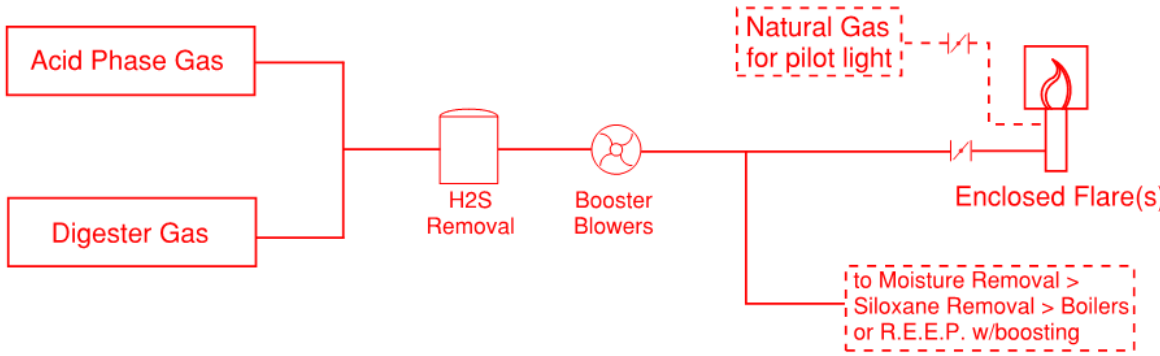


Figure 7.6-10: Schematic of Waste Gas Flare Alternative 1B

7.6.15.4 Alternative 2: Separate Gas Streams - Acid-Phase Gas to Thermal Oxidizer and Excess Digester Gas to Flares

The acid-phase gas will be piped to and eliminated by a thermal oxidizer. To protect various operating components of the thermal oxidizer, including the combustion air recuperator or heat exchanger, a siloxane removal system is included. As a prerequisite for this, a moisture removal system with a chiller is included to protect the siloxane removal media. Natural gas will supplement the thermal oxidizer both to pre-heat and maintain heat in the combustion chamber, as needed.

The digester gas flares are used only when there is excess gas flow or if the gas utilization system is out of service.

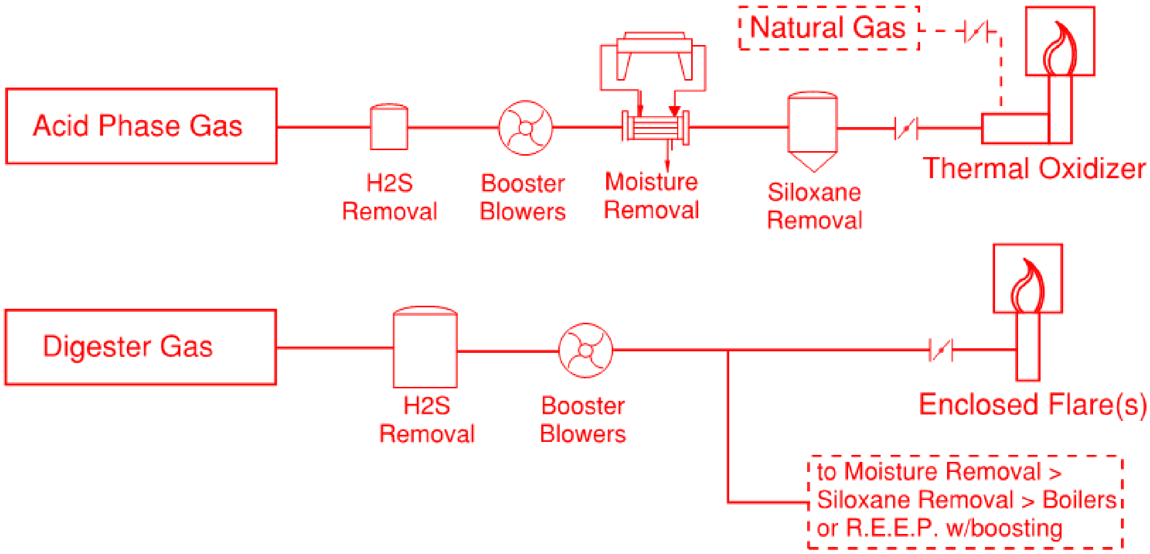


Figure 7.6-11: Schematic of Waste Gas Flare Alternative 2

7.6.15.5 Alternative 3: Separate Gas Streams - Acid-Phase and Excess Digester Gas to Separate Flares

Acid-phase gas will be combusted by a single flare. The digester gas flares only operate to combust excess gas flows or if the gas utilization system is out of service. H_2S removal and gas pressurization is provided as required.

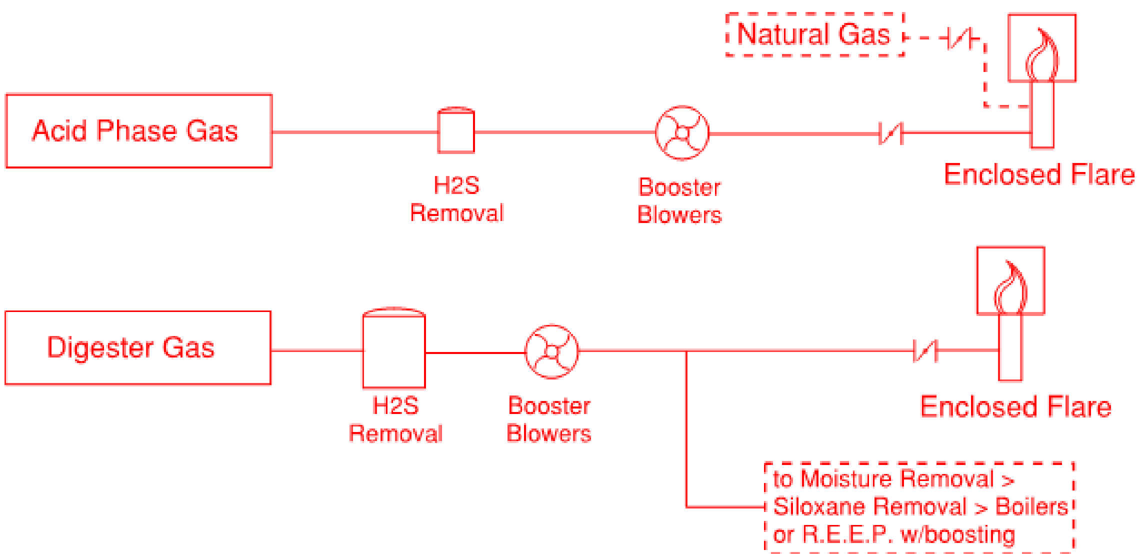


Figure 7.6-12: Schematic of Waste Gas Flare Alternative 3

7.6.16 Updated BCE for Waste Gas Flares

A BCE was performed on ultimately four alternative methods for the burning of waste gas. These various configurations included: H_2S removal, gas pressurization, and the waste gas burning technology. This evaluation took into account the initial capital cost of each alternative and the expected O&M costs resulting in a NPV over a span of 23 years for each. Capital costs are inputted for year 2022 and the O&M costs are annualized from 2023 to 2045. A summary of the results of this updated BCE is included in the table below.

Table 7.6-12: Summary of Updated BCE for Waste Gas Flares

Alternative	Description	Capital Costs	NPV
1A	Flare Combined Streams; Duplex Treatment	$7,160,000	$13,440,000
1B	Flare Combined Streams; Merged Treatment	$4,630,000	$6,920,000
2	Flare and Thermal Oxidizer	$8,030,000	$13,630,000
3	Flare Separate Streams	$6,370,000	$11,645,000

(1) Capital costs shown are un-escalated 2016 dollars
(2) O&M and R&R costs shown are escalated and discounted back to 2016 dollars.

7.6.17 Updated Recommendation for Waste Gas Flares

As a result of the BCE, the recommended gas elimination and configuration is Alternative 1B. With the lowest capital costs total and NPV, this configuration maximizes the beneficial utilization of all biogas methane produced by the digesters, both acid-phase and digester gas. As opposed to all other alternatives, the flares will only operate when needed to eliminate excess gas flows or when the gas utilization is out of service. The recommended alternative also reduces the number of H_2S removal systems and gas booster blowers, further simplifying operation and maintenance.

Below is the recommended preliminary waste gas flaring schematic in slightly more detail. Redundancy is recommended for both the H_2S removal system and the gas booster blowers, both of which are critical components in the waste gas flaring process. As previously mentioned there are two independent flares, of differing sizes and capacities, needed to turn down for the lower gas flows while still meeting the maximum case capacity.

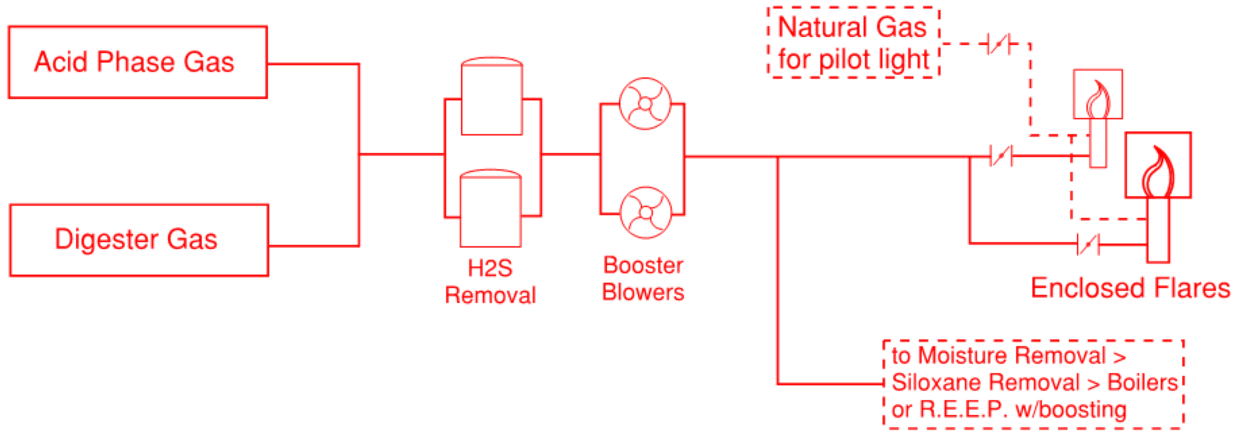


Figure 7.6-13: Schematic of Recommended Alternative 1B in More Detail

7.7 EVALUATION OF RP-5 ODOR CONTROL ALTERNATIVES

7.7.1 Introduction

This introductory section presents a project background, understanding and design approach, for several odor control alternatives applicable to the RP-5 project. Each alternative is considered from a performance, operating, and BCE perspective. The BCE is a life-cycle benefit/cost analysis based on the NPV. NPV analysis is the most comprehensive method to make investment decisions by considering the total cost of a project over its entire life. Because costs or revenues may occur at different times during the duration of the project, time-value of money equations can be used to calculate the present value of all costs and revenues over the life cycle of a project.

The purpose of this BCE this to provide sufficient comparative information on costs, benefits, and risks of the alternatives to provide a sound basis for technology selection. Sizing, loading, process configurations, layouts, and costs are based on project parameters agreed on by the project team and Agency staff at the time of commencing the BCEs. Since evaluations of technologies and other important project conditions were conducted in parallel and results can impact the final configurations, refinement of the final selected alternative and costs will be conducted after the BCE and technology selection described in this chapter. This refinement will be reflected in the Approved Project Requirements document and integrate into the design final decisions made by the Agency on project phasing, final load decisions related to FW and FOG treatment, staff layout and configuration preferences, and other decisions subsequent to the BCE.

Based on the background of the project, the new solids treatment facility at RP-5 would consist of Thickening, Digestion, and Dewatering. It is recommended that odor control be added to the Thickening and Dewatering processes since these have the most potential for fugitive odorous air emissions. Gas produced in the Digestion process is treated using a dedicated gas storage and treatment system.

This BCE will evaluate three different technologies for odor control and arrive at the most cost-effective option for selecting a technology. Following are the alternatives we considered for odor control:

- Chemical scrubbing

- Bioscrubbing
- Biofiltration
- Activated carbon

7.7.2 Foul Air Production and Characteristics

7.7.2.1 Foul Air Sources

The odor control systems will treat foul air that is collected from the thickening and dewatering equipment, and truck loadout operations. Equipment that can be hooded or totally enclosed will contain and capture odorous air with relatively low airflow. This approach treats foul air from the equipment only, as opposed to treating the entire room volume. This allows the odor control system capacity to be reduced, significantly decreasing the size and cost of the system.

The BCEs for Thickening and Dewatering included evaluating different technologies, each with slightly different air flow requirements. The odor control systems will be sized to accommodate the air flow from the selected technologies based on the results of those BCEs. The air flow rates and design criteria are summarized below in Table 7.7-1.

Table 7.7-1: Sources of Foul Air and Design Criteria

Location	Source	Design Criteria	Air Flow Rate per unit	Total Air Flow
			cfm	cfm
Thickening Building	RDT	Per Manufacturer	430	3,000
	Sludge Blend Tanks	Leakage Rate, 0.5 cfm/ft^2	300	300
	Thickened Sludge Tanks	Leakage Rate, 0.5 cfm/ft^2	50	50
	Filtrate Tanks	Leakage Rate, 0.5 cfm/ft^2	50	50
			TOTAL	**3,400**
Dewatering Building	Centrifuge	Per manufacturer	400	1,000
	Conveyors	5 cfm/ft	200	1,000
	Cake Bins	Leakage Rate, 1 cfm/ft^2	500	1,000
	Truck Load Out Room	12 ACH	8,500 (per bay)	17,000
	Centrate Storage Tanks	Leakage Rate, 1 cfm/ft^2	1,000	2,000
			TOTAL	**22,000**

7.7.2.2 Foul Air Characteristics and Design Parameters

Table 7.7-2 summarizes the foul air characteristics and performance criteria. Since the solids processes are not existing, sampling and testing for common odor constituents cannot be conducted, therefore, assumed values typical for these processes should be used for designing the odor control systems. It is recommended that sampling be conducted after construction and startup of the facilities to obtain actual data relevant to RP-5.

Table 7.7-2: System Design Parameters for Odor Control Systems

Constituent	Average Concentration	Peak Concentration	System Removal Efficiency
Hydrogen Sulfide, ppm	2	6	97%
Other Reduced Sulfur Compounds	0.5	2	90%

7.7.2.3 Odor Control System Design Criteria

Table 7.7-3 lists the assumed design parameters for the different technologies.

Table 7.7-3: System Design Parameters for Odor Control Systems

Item	Biofilter	Bioscrubber	Activated Carbon
System Type	Open Bed	Tower	Dual Bed
Empty Bed Contact Time, sec	45	15	2.5
Pressure Drop Across Media, inches w.c.	8	4	8
Design Approach Velocity, ft/min	< 5	50–70	< 60

7.7.2.4 Accepted Odor Removal Goals

A quantitative odor limit of 5 dilutions-to-threshold (D/T) at the fence line represents the regulatory standard that can be applied by the SCAQMD if triggered by complaints. As the term implies, the detection threshold (dilution to threshold) is a measure of odor strength for any given odor sample. The olfactometry test to determine odor strength is relatively complicated in its test apparatus and methods. But the results (simply put) is the number of fresh-air dilutions to a sample that renders the sample "non-odorous to an odor panel of at least eight individuals." High D/T samples reflect strongly odorous samples requiring considerable amounts of dilution air to render a sample non-odorous. A similar value is the recognition threshold which is defined as the lowest concentration where the odorant can be specifically identified, instead of broadly quantified as a noticeable odor. In low concentrations, H_2S roughly correlates to approximately 2 D/T for part per billion of H_2S in a sample. Ammonia produces much less of an odor impact. Concentrations above 1 ppm ammonia are usually required to produce a measureable D/T value.

The 5 D/T fence line value with a 1-hour averaging period and 99% compliance has been adopted as a design requirement consistent with the Agency's goal of no detectable odors at the fence line. This is normally the D/T concentration that is considered "zero odor," since normal urban atmospheres usually test at least 5 D/T to 10 D/T, in the absence any known odor source contributors.

The fence line criteria of 5 D/T is consistent with several wastewater treatment authorities in California and elsewhere as shown below in Table 7.7-4 below.

Table 7.7-4: Examples of Wastewater Treatment Authorities Design Criteria

Facility/Agency	Standard	Averaging Time	Compliance
BAAQMD, San Francisco, CA.	5 D/T	-	-
Cincinnati WWTP, OH	7 D/T	3 minutes	90%
Dublin San Ramon Services District, Dublin, CA	4 D/T	1 hour	99%
East Bay Municipal Utility District, Oakland, CA	5 D/T	1 hour	99%
Fairfax, VA	7 D/T	1 hour	100%
Hampton Roads Sanitation District, VA	5 D/T	1 hour	99%
Orange County Sanitation District, CA	15 D/T	3 minutes	
San Diego WWTP, CA	5 D/T	5 minutes	99.5%
Sacramento County Regional Sanitation District, CA	10 D/T	1 hour (assumed)	
Wilsonville, OR	5 D/T	1 hour	
Spokane, WA	7 D/T	1 hour	

The averaging time indicated in the table, is also an important factor for the odor goal. For dispersion modeling, the level of refinement of results is usually one hour, since the models typically rely on hourly meteorological data records. Shorter time frames can be considered, but they usually much higher than the hourly average and represent transient conditions, not representative of routine odor conditions from a source. Based on the above reasons, a 1-hour averaging time for modeling evaluations of compliance with the 5 D/T criterion and 95% compliance is recommended. It should be noted that 95% compliance is considered realistic to allow for operations activities including short-term opened doors/hatches and unplanned plant upsets. It is also appropriate to note, that control equipment does not require exhaust concentrations at these values, since the exhaust from any odor control unit will achieve additional air dilution prior to reaching the fence line. Dilution factors of at least 10 and as much as 50 can be experienced, depending on specific site factors.

7.7.3 Odor Control Technology Alternatives

Several techniques are used to treat odors. A combination of control measures is often used to achieve effective and economical control. H_2S is the main constituent in many wastewater odors. Therefore, most treatment processes focus on removing H_2S to reduce odors.

Some odor control treatments are significantly more effective on H_2S than on other odorants. Since H_2S is ionic in nature, gas scrubbing and absorption systems are effective for gas phase control. Dry biofilters, or wet bioscrubbers are also very effective H_2S removal systems and have the significant advantage of not requiring chemicals for absorption and oxidation of H_2S. Activated carbon adsorption is a dry technology relying on the adsorption affinity of H_2S and other VOCs, by activated carbon. It is a superior technology for conditions in which non-H_2S compounds are prevalent and difficult to remove by conventional biological or chemical means. Sulfide precipitation with liquid phase chemicals can help reduce the odor emissions levels from the wastewater if H_2S concentrations become overly high. This is usually considered a collections system sulfide control approach, but can have positive benefits to treatment plant odor control systems. Reduced sulfur compounds and VOCs often require a different treatment technique than that needed for H_2S control. Air streams with these odor constituents normally are treated with activated carbon after H_2S removal. Processes requiring sludge treatment and handling usually present a more complex mixture of odorous compounds, and should consider multistage processes combining different control technologies.

7.7.3.1 Chemical Scrubbing

Wet chemical scrubbers treat odorous air by using oxidizing chemicals in a counter-current packed bed tower. Foul air is conveyed from different processes into a vessel, where it flows counter-current to the chemical liquid. Sodium hypochlorite and caustic soda are commonly used in wet chemical scrubbers to oxidize the H_2S and other reduced sulfur compounds. The caustic soda maintains high pH to ionize the H_2S and drive the sulfide into solution and the sodium hypochlorite oxidizes the dissolved sulfide, converting it into dissolved sulfate and elemental sulfur. Chemical scrubbers consist of a liquid sump, recirculation pump, gas inlet, packed bed media, spray nozzles and a demister and gas outlet. In addition to the scrubber towers, a chemical storage facility is also required to store and convey the chemical to the packed tower.

One advantage of chemical scrubbing is the capacity to treat high air flow volumes and high gas loadings. Also, because chemicals are used to raise the pH of the fluid within the vessel, the chemical reaction between the gas and liquid phases only requires a 1 second to 2 second contact time. Thus, relatively small vessels can handle high air flows. Another advantage is that chemical scrubbers require no acclimation time and can achieve 98% to 99% efficiency almost immediately after startup. Contrary to the biological treatments, chemical scrubbers do not require any lead time for biological growth and foul air may be treated in a separate vessel simply by transferring the air flow to the redundant vessel.

The disadvantages to chemical scrubbing are that it can be very costly and complex to operate. Chemical usage is one of the significant costs associated with chemical scrubbing. The chemicals also require handling and storage, which is another added expense. Maintaining the system chemistry within the scrubber and the components required to monitor system chemistry add to high maintenance hours required to operate the system and add complexity to the system. Any problem condition such as pump failure, air binding in chemical lines, or pH or oxidation reduction potential measuring errors, almost immediately causes a significant drop in performance.

7.7.3.2 Biofiltration

Biofiltration is an odor control technique that uses a bed of porous and moist medium that support micro-organisms that absorb and oxidize odorous constituents. Biofilters can be constructed either as open systems exposed to atmosphere or packaged enclosed aboveground systems. Space requirements for biofilters is significant as the air through-put velocity is normally between 3 ft and 5 ft per minute. Influent air is typically spray-humidified prior to the biofiltration process to maintain adequate moisture in the media. Media sprinklers are also used for moisture maintenance, although total water use is relatively low. An organic biofilter requires somewhat high residence times (45 seconds to 90 seconds) and low velocities to effectively treat the odorous compounds. Newer inorganic media manufactured by vendors can reduce residence times to 30 seconds. These medias produce lower pressure drop, longer life, and greater ability to flush and clean the system. They do require a considerable cost premium as they are an “engineered media.” Figure 7.7-1 illustrates a process flow diagram of a biofiltration system.

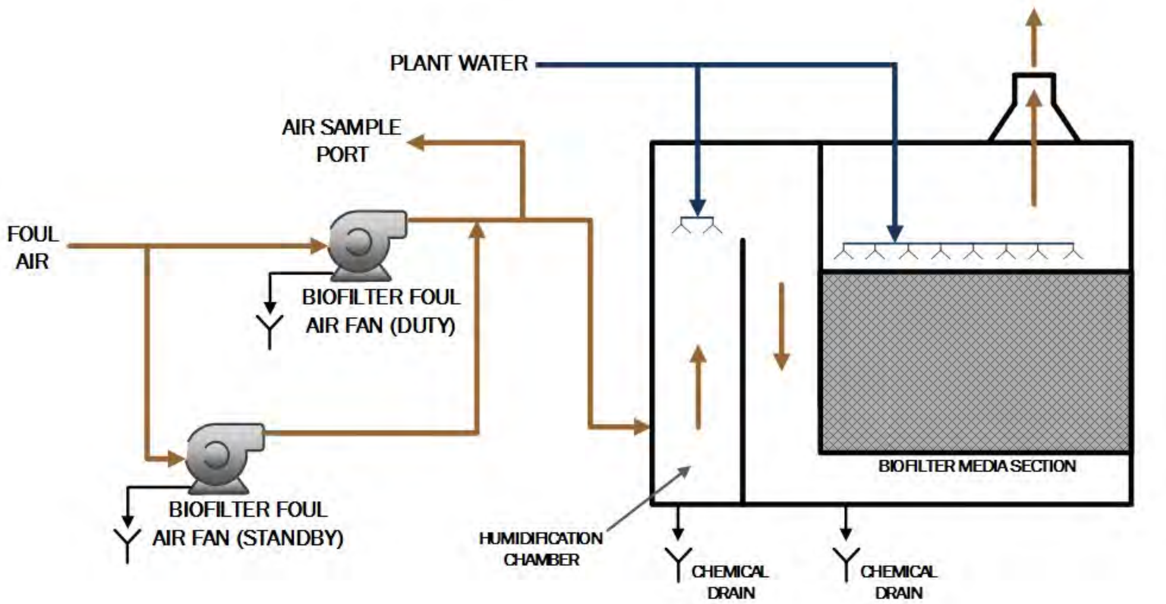


Figure 7.7-1: Biofilter Process Flow Diagram

7.7.3.3 Bioscrubbing

Similar to biofiltration, bioscrubbing is another environmentally friendly odor control treatment that also treats foul air using biological micro-organisms. However, a bioscrubber appears similar to a normal vertical chemical scrubber, operating at much higher throughput than a biofilter. The differentiator between the bioscrubber and the biofilter is that in addition to biodegradation, the bioscrubber also utilizes absorption, adsorption and condensation to treat the contaminants in the foul air. In bioscrubbers, highly soluble compounds are transferred from the gas phase into the aqueous phase (H_2S is highly soluble in water) and the compounds with low water solubility may be physically adsorbed into the biological flocs. Odorous gas will also condense when it is contacted with an aqueous medium at a lower temperature. Bioscrubbing is essentially a liquid process whereas biofiltration is considered a dry process.

Bioscrubbers may consist of counter-current packed towers that are comprised of a liquid sump, recirculation pump, gas inlet, packed bed media, spray nozzles and a demister and gas outlet. The influent air enters the packed tower and flows counter-current to the liquid. The packed bed is filled with randomly placed low-pressure, high-efficiency plastic packing. A custom designed bioscrubber such as a concrete tower structure may be a viable option to allow a decrease in the system footprint and greater air flow. A bioscrubber has the capacity to withstand higher loading rates in a smaller space requirement. Where biofilters are loaded at 3 ft^3 to 4 ft^3 per minute per square foot (cfm/ft^2) of area and have 45 seconds to 90 seconds of residence time, bioscrubbers are loaded to 50 cfm/sf to 100 cfm/sf and operate with 5 seconds to 10 seconds residence. The disadvantage to a bioscrubber is that treatment is limited to water soluble compounds and H_2S removal efficiency is less (< 95%), unless residence time is increased beyond 10 seconds. Systems needing to achieve 99% or greater removal efficiency should be followed by activated carbon for polishing.

Figure 7.7-2 illustrates a process flow diagram of a bioscrubber system.

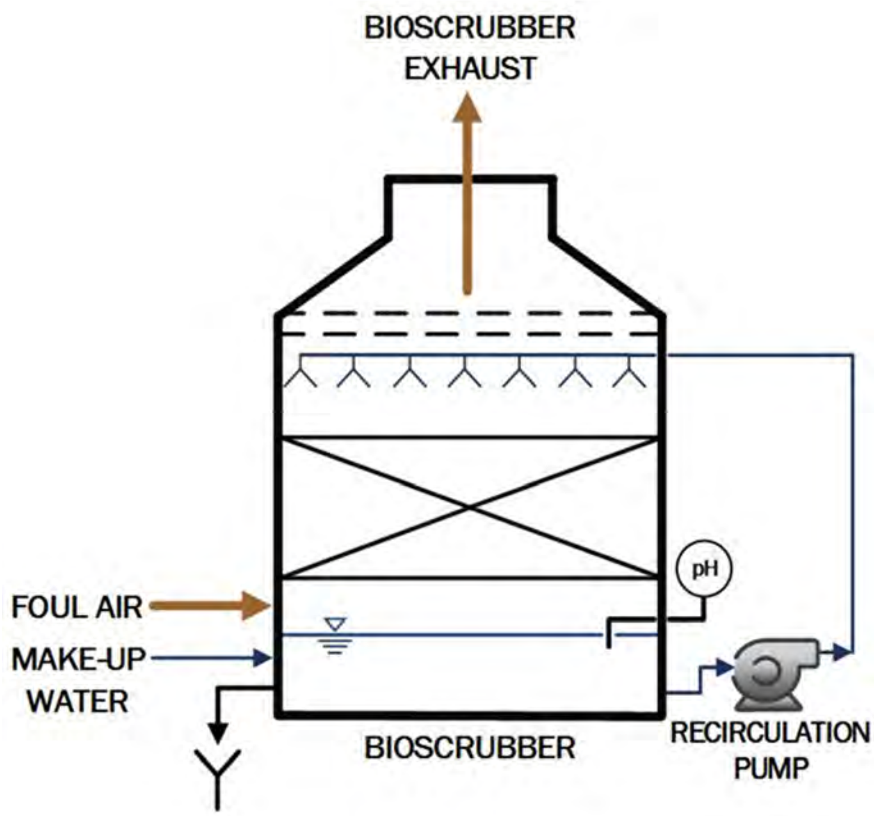


Figure 7.7-2: Bioscrubber Process Flow Diagram

7.7.3.4 Activated Carbon

Activated carbon is used to reduce odorous air by using the adsorption process. Odorous air is passed through a packed bed of activated carbon and the H_2S, as well as other odorous reduced sulfur compounds, are adsorbed into the pores of the carbon. Activated carbons that are the most effective on typical wastewater odors include coal and coconut-based carbons and catalytically enhanced carbon. Activated carbon is capable of treating volatile organic compounds and low to moderate levels of H_2S. The general rule of thumb for using activated carbon as a treatment option is in applications where H_2S concentrations are less than 10 ppm. Activated carbon is often used as a second stage, polishing step to another technology. An activated carbon system consists of a fan, vessel and exhaust stack. Vessel configurations can be vertical, horizontal or radial and can consist of a single bed or dual beds. An example of a process flow diagram for a vertical dual bed is shown in Figure 7.7-3 below.

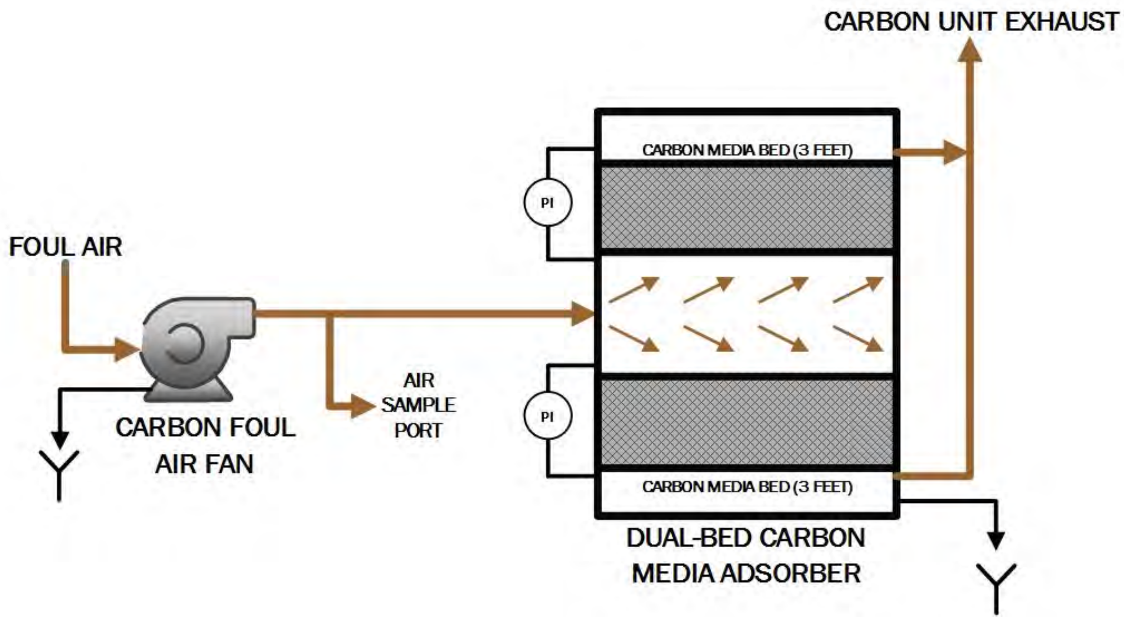


Figure 7.7-3: Activated Carbon Dual Bed Process Flow Diagram

7.7.4 Odor Control Alternatives Screening

7.7.4.1 Screening Criteria

The odor control technologies were initially screened to determine if all technologies meet IEUA minimum requirements using a pass/fail approach. A high level rating on a scale of 1 to 5 was also provided for criteria considered important and weighted averages computed. The results are provided in Table 7.7-5.

Table 7.7-5: Results of Initial Screening Evaluation

Odor Control Alternatives	Weight	Chemical Scrubbing	Bioscrubbers	Biofilters	Activated Carbon
Supports Treatment and End Use Objectives	Pass/Fail	YES	YES	YES	YES
Meets Required Performance	Pass/Fail	YES	YES	YES	YES
Proven Technology	Pass/Fail	YES	YES	YES	YES
Acceptable Complexity	Pass/Fail	YES	YES	YES	YES
Capital Costs	10%	3	4	3	4
Power and Operating Costs	20%	2	4	4	3
H_2S and Odor Removal Efficiency	25%	5	4	5	4
Response to High Odor Loads	10%	5	4	3	1
Operating Complexity	10%	1	5	5	5
Space Requirement	10%	3	4	2	4
Chemical Storage and Handling Requirement	10%	1	5	5	5
O&M Requirement	5%	1	5	5	4
Weighted Average		**3.0**	**4.3**	**4.1**	**3.7**

7.7.4.2 Screening Recommendation

Based on the scores of the screening criteria for the odor control alternatives, BC recommends comparing biofiltration, activated carbon and combined system comprising of bioscrubbing (1st stage) and activated carbon (2nd stage). Chemical scrubbing received the lowest score mostly due to operational complexity, the requirement to store and handle hazardous chemicals and the O&M requirements to maintain chemical deliveries and system components for proper performance. Due to the high sensitivity of the surrounding area and goal of little to no odors at the fence line, it is recommended that bioscrubbing be analyzed as a two-stage system with activated carbon as a polishing step. Bioscrubbers typically maintain a 90% to 95% H_2S removal efficiency with very little reduced sulfur compound removal. Thus, a restrictive fence line odor requirement will benefit from the second stage activated carbon polishing.

In all cases, the screening level recommendations assume that some systems may operate intermittently, such as dewatering presses, and airflow from tank headspaces, wet wells, and truck bays, to provide some level of continuous odorous air to the odor control system. This enables biological systems to maintain a minimum level of biological activity. This airflow may be reduced due by variable airflow fans, based on dewatering operating schedules.

7.7.5 Odor Control System Alternatives Business Case Evaluation

This section presents an equipment evaluation and comparison of the odor control technologies, including a summary of BCE results. The IEUA standard BCE template was used to develop comparative net present values for odor control facilities constructed in 2022 and operating through 2045.

7.7.5.1 Capital Costs

The capital costs for the odor control technologies are presented in Table 7.7-6. The systems used for analysis are biofiltration, activated carbon and bioscrubbing plus activated carbon. Also, the assumed capacity for analysis was 36,000 cfm.

Table 7.7-6: Odor Control System Capital Cost Comparison

Technology	Capital Cost
Biofilter	$4,800,000
Activated Carbon	$3,000,000
Bioscrubber plus Activated Carbon	$6,300,000

7.7.5.2 Operations and Maintenance Considerations

Table 7.7-7 lists the parameters used for comparison of the odor control alternatives. Conversations with Agency staff indicate that the existing biofilter media requires change out approximately every 5 years or less. Also, it is assumed that carbon will only need to be replaced every 5 years because it is a polishing step. Another potential operational approach is to only operate the activated carbon when the thickening and dewatering processes are operational. When they are not operational, the foul air would only be treated through the bioscrubber. This would require some motor operated dampers on the duct interlocked such that they would open and close to direct foul air to the appropriate treatment system. This would reduce the frequency of carbon media replacement and ultimately save O&M cost.

Table 7.7-7: Operations and Maintenance Parameters

Parameter	Biofilter	Bioscrubber	Carbon
Media Replacement Cycle, yrs	5	20	5
Power Cost, $/kWh	$0.125	$0.125	$0.125
Power Usage, kW	24	48	48
Water Cost, $/1,000 gal	$2.20	$2.20	$2.20
Water Usage, gph/cfm	0.012	0.008	0
Operating Hours per Year	8,000	8,000	8,000
Labor Rate Per Hour	$96.33	$96.33	$96.33
Labor Requirement, hours/mo	12	6	6

7.7.5.3 Business Case Evaluation Results and Analysis

Results of the BCE are provided below in Table 7.7-8. All costs are in 2016 dollars. The full BCE spreadsheet is presented in Exhibit I of this Volume.

Table 7.7-8: Results of the Business Case Evaluation

Alternative	Capital (1)	O&M (2)	NPV
Biofiltration	$4,800,000	$8,408,000	$13,200,000
Activated Carbon	$3,000,000	$4,234,000	$6,600,000
Bioscrubbing with Carbon Polishing	$6,330,000	$3,142,000	$12,000,000

(1) Capital costs shown are un-escalated 2016 dollars
(2) O&M costs shown are escalated and discounted back to 2016 dollars.

7.7.6 Odor Control System Summary

7.7.6.1 Screening Level Odor Control System Factors

An initial screening was completed to compare the major features of various odor control alternatives. The comparison of the odor control alternatives suggests the following:

- Bioscrubbers received the highest score of the odor control technologies evaluated on a screening-level basis. The screening level evaluation factored in capital cost, odor removal efficiency, footprint, and ease of operation.
- Bioscrubbers with activated carbon as a polishing step result in a significantly higher capital cost but provide greater odor removal, improved operating flexibility, and no loss of odor treatment if either system is off-line. O&M costs and overall NPV are slightly lower than a biofilter costs assuming relatively frequent biofilter media replacement.
- Activated carbon as a single stage odor control option, results in the lowest NPV value. Activated carbon is an appropriate technology for low H_2S applications (less than 10 ppm). However, activated carbon has an implied carbon cost for each pound of odorant removed.

Biological processes do not have this cost as the processes rely on biological assimilation of the odorants. Thus, higher H_2S and odor loads skew the costs benefits to a biological option. The odor control system used to treat foul air from the dewatering building may be a good candidate for activated carbon depending on the actual concentrations. Experience elsewhere has shown that dewatering odors have low H_2S concentrations, but overall D/T odor concentrations that are somewhat high. Treating that source in single stage activated carbon is a viable alternative.

Providing one centralized odor control system to treat all areas has also been evaluated. Centralizing odor control has obvious cost benefits, but may also produce more consistent odor loads to a biological process. More details regarding the size the potential locations for a centralized system are provided in Volume II, Chapter 7: Evaluation of RP-5 Liquid Treatment Alternative Technologies (specifically Chapter 7.5 Odor Control).

7.7.6.2 Odor Control System Operating Conditions

Based on conversations with IEUA staff, there are operating conditions that can affect the inlet H_2S concentrations and the performance of the odor control system.

1. Ferric chloride addition to the influent typically reduces H_2S odors at virtually all downstream plant processes. Decreased H_2S emissions from the primary clarifiers and from digestion processes is the main odor benefit of ferric chloride.
2. Sludge dewatering occurs intermittently. At this time, it is anticipated that the dewatering processes will operate 5 days a week, 8 hours per day. Therefore, odor control effectiveness is best accomplished by blending the dewatering odor sources with other foul airstreams: (centralized concept), or to systems such as activated carbon, that can be on-line and effective within minutes.

7.7.6.3 Dedicated Odor Control System for Dewatering

Inconsistent H_2S loading to the odor control system will occur under intermittent sludge dewatering operation. Intermittent odor loads to a bioscrubber may produce variations in odor removal efficiency, as the bioscrubber may not respond quickly to large changes in loads. There are a couple of provisions that can be made and should be evaluated further during the design phase. One is to add a bypass duct to the dewatering foul air duct to allow the option to treat directly in the carbon system. Another option would be to add provisions to the duct to allow the foul air from the thickening processes to combine with the foul air from the dewatering to provide consistent source of H_2S.

It is recommended that samples be collected after the system is operational. This will help to determine the concentrations and odor constituents prior to treating it solely with activated carbon. Activated carbon may be an economical and appropriate technology for low H_2S applications (less than 10 ppm). If the concentrations are greater than 10 ppm, it could lead to frequent media replacement and increase the O&M costs. The higher costs would likely justify a biological scrubber for pretreatment of the odorous air prior to carbon polishing.

7.7.7 Agency Decisions and Preferences for the Approved Project Requirements

The purpose of this section is to document recent IEUA direction/preferences provided during the BCE workshop on August 11, 2016, that are not included in this evaluation but deferred to the approved project deliverable. This evaluation would only be updated to address minor comments that would have the potential for affecting the technology selection. The impact on odor control equipment size, number, layout, and cost will be evaluated at the next detailed design phase of the project.

Major items to be integrated into the Approved Project Requirements include:

- Evaluation of one centralized treatment system to treat foul air from all foul air sources from the primaries, thickening, and dewatering processes through conveyance of foul air across site. Items include further evaluation on average and peak odor concentrations, physical size of the system, possible locations and cost differences between conveyance of air across the site compared to dedicated systems at each area.
- Further analysis of system redundancy to ensure compliance during a system failure or during an outage due to routine maintenance.
- Review options to ensure a negative pressure is maintained in equipment and structures and provide cost for increased levels of reliability.
- Understanding process operations and how they would affect the performance on the odor control system by changing the assumed design H_2S concentrations. This may include rapid sludge withdraw, adding ferric chloride upstream of the plant, and combining foul air sources or keeping them separate. Provide flexibility in the design to allow for slight changes in concentrations.

7.7.8 Recommendations

Based on the assumed design parameters, the overall recommendation for a centralized odor control system for the primary, thickening, and dewatering processes at the RP-5 facility is a 2-stage system consisting of bioscrubbing with activated carbon polishing system.

- The BCE is supportive of this option. The BCE was evaluated using a media replacement frequency of 5 years for biofilters because the IEUA historically has had to change out the media every 5 years or less. Inorganic media has a longer life expectancy but at somewhat greater cost. IEUA has experienced operational and performance issues with their organic media biofilters. This suggests that this technology may not be sufficiently reliable and produce the level of odor removal and ease of operation that is essential for the odor control system.
- This recommendation provides two stages of treatment which will help the IEUA to meet the target odor concentration goal at the fence line. Two stages of treatment also provide inherent redundancy such that if one system needs to be maintained, the other system can be used for treatment during the maintenance period.

Bioscrubber with carbon was selected as the preferred alternative by the IEUA at the August 11, 2016, BCE workshop. Having the solids thickening and dewatering follow this approach, provides consistency with odor control on the liquid treatment processes.

APPENDIX 7-A: RP-1 AND RP-5 EXPANSION FLOW VALIDATION

THIS PAGE INTENTIONALLY LEFT BLANK.

APPENDIX 7-B: RP-5 AND CCWRF SLUDGE QUANTITY ESTIMATES

THIS PAGE INTENTIONALLY LEFT BLANK.

RP-1& RP-5 Expansion Flow Validation

Project Nos. EN16025 & EN16028

April 2016

Inland Empire Utilities Agency

A MUNICIPAL WATER DISTRICT

Jason Marseilles, P.E.,
Senior Engineer

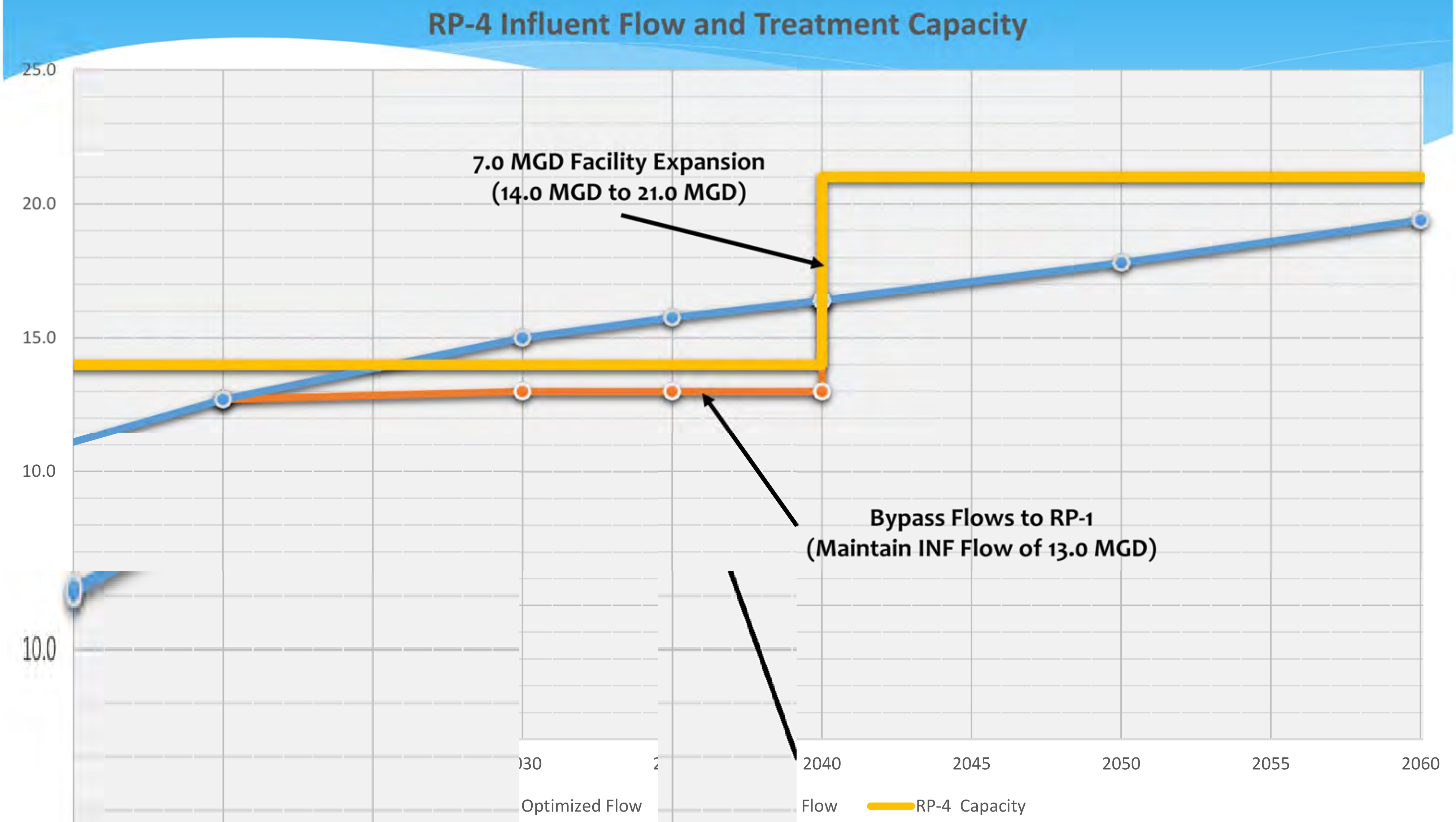
Agency Flow Forecast

WFMP Projected Facility Sewer Flows with Diversions

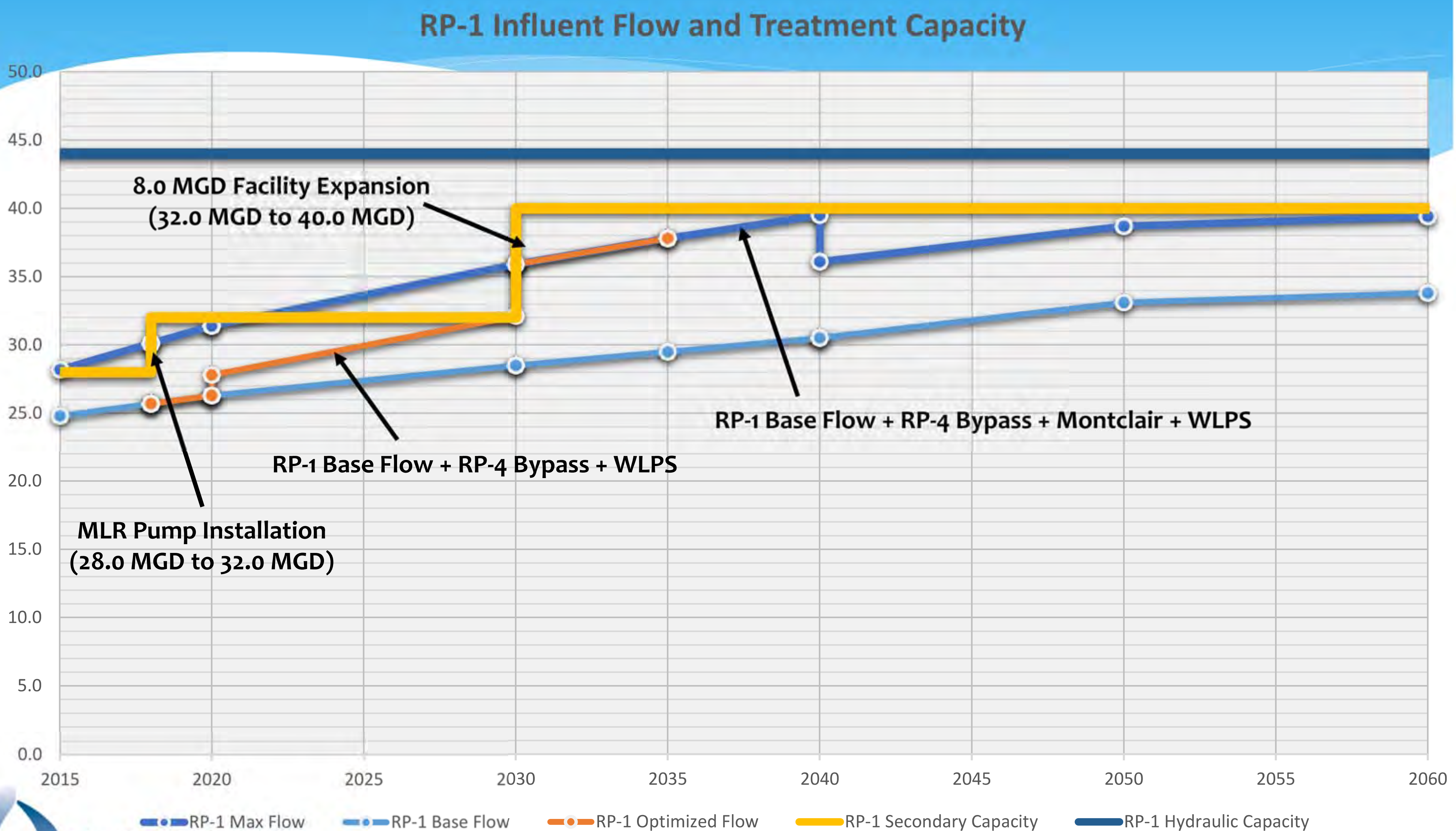
		Tributary Areas	2013 Flow (MGD)	2020 Flow (MGD)	2030 Flow (MGD)	2035 Flow (MGD)	2040 Flow (MGD)	2050 Flow (MGD)	2060 Flow (MGD)
RP-4									
	Gravity Flow	CW-07,CW-07BT, CW-A, F-17, F-18, & F-1	6.5	7.0	8.2	8.6	8.9	9.6	10.4
	San Bernardino Lift Station Flow	F-1SB & F-SB_A	4.6	4.7	5.3	5.4	5.5	5.7	6.0
	Converted Septic Flow[1]	F-1SB_B, F-SB_B, F-9FT	0.0	1.0	1.5	1.8	2.0	2.5	3.0
	RP-4 Max Flow[2]		**11.1**	**12.7**	**15.0**	**15.8**	**16.4**	**17.8**	**19.4**
RP-1									
	Gravity Flow	C-13, C-15, CW-01BT, CW-02BT, CW-08,	19.4	20.3	21.9	22.7	23.4	25.5	25.7
	Gravity Flow (Potential RP-4 Trunk)	RP4-1T & RP4-2T	5.3	5.4	5.4	5.4	5.4	5.4	5.4
	Converted Septic Flow	Parcel Count (8,679 x 5 c/parcel x 55 gpc	0.0	0.5	1.0	1.3	1.5	2.0	2.5
	RP-4 Bypass[3]	Bypass at Headworks or SBLS	0.0	0.0	2.0	2.8	3.4	0.0	0.0
	Montclair Diversion Flow	M-1 & P-U3	3.4	3.6	3.8	3.8	3.9	3.9	3.9
	Whispering Lakes PS Flow	OA-1B	1.5	1.5	1.6	1.6	1.7	1.7	1.7
	Haven PS Flow[4]	O-31, O-32, O-33A, O-42, O-43, & O-48	0.1	0.1	0.2	0.2	0.3	0.3	0.3
	RP-1 Max Flow[5]		**29.7**	**31.4**	**35.9**	**37.8**	**39.5**	**38.7**	**39.4**
CCWRF									
	Gravity Flow	C-1N, C-3A:C-9, C-12, C-14, C-16:C20, & (	7.4	7.6	7.8	7.9	8.1	8.3	8.5
	Montclair Diversion Flow	M-1 & P-U3	3.4	3.6	3.8	3.8	3.9	3.9	3.9
	CCWRF Max Flow		**10.8**	**11.2**	**11.6**	**11.7**	**11.9**	**12.2**	**12.4**
RP-5									
	Gravity Flow	C-1B:C-2, C-10, C-11, C-21, CA-1:CA-3, CH	3.8	6.4	11.5	13.7	16.0	19.3	19.6
	Preserve Lift Station Flow	CA-4, CIW_A & CIW_B	0.2	1.3	2.0	2.2	2.5	3.0	3.3
	RP-2 Lift Station Flow (No Recycle)	C-1D, CH-5, CH-7, SB-6A, & SB-6B	0.3	0.3	0.3	0.3	0.3	0.4	0.4
	Montclair Diversion Flow	M-1 & P-U3	3.4	3.6	3.8	3.8	3.9	3.9	3.9
	Whispering Lakes PS Flow	OA-1B	1.5	1.5	1.6	1.6	1.7	1.7	1.7
	Haven PS Flow	O-31, O-32, O-33A, O-42, O-43, & O-48	0.1	0.1	0.2	0.2	0.3	0.3	0.3
	CIM Flow		0.0	0.9	0.9	0.9	0.9	0.9	0.9
	Additional Buffering Capacity		0.0	0.0	0.0	0.0	0.0	0.0	0.0
	CCWRF Base Flow	C-1N, C-3A:C-9, C-12, C-14, C-16:C20, & (	7.4	7.6	7.8	7.9	8.1	8.3	8.5
	RP-5 Base Flow		**5.8**	**8.1**	**13.7**	**16.3**	**18.8**	**22.7**	**23.2**
	RP-5 with Max. Diversion		**9.3**	**14.2**	**20.2**	**22.8**	**25.5**	**29.4**	**29.9**
	RP-5 Max Flow with CCWRF Flow		**16.7**	**21.8**	**28.0**	**30.7**	**33.6**	**37.8**	**38.4**

Inland Empire Utilities Agency
A MUNICIPAL WATER DISTRICT

RP-4 Flow Forecast

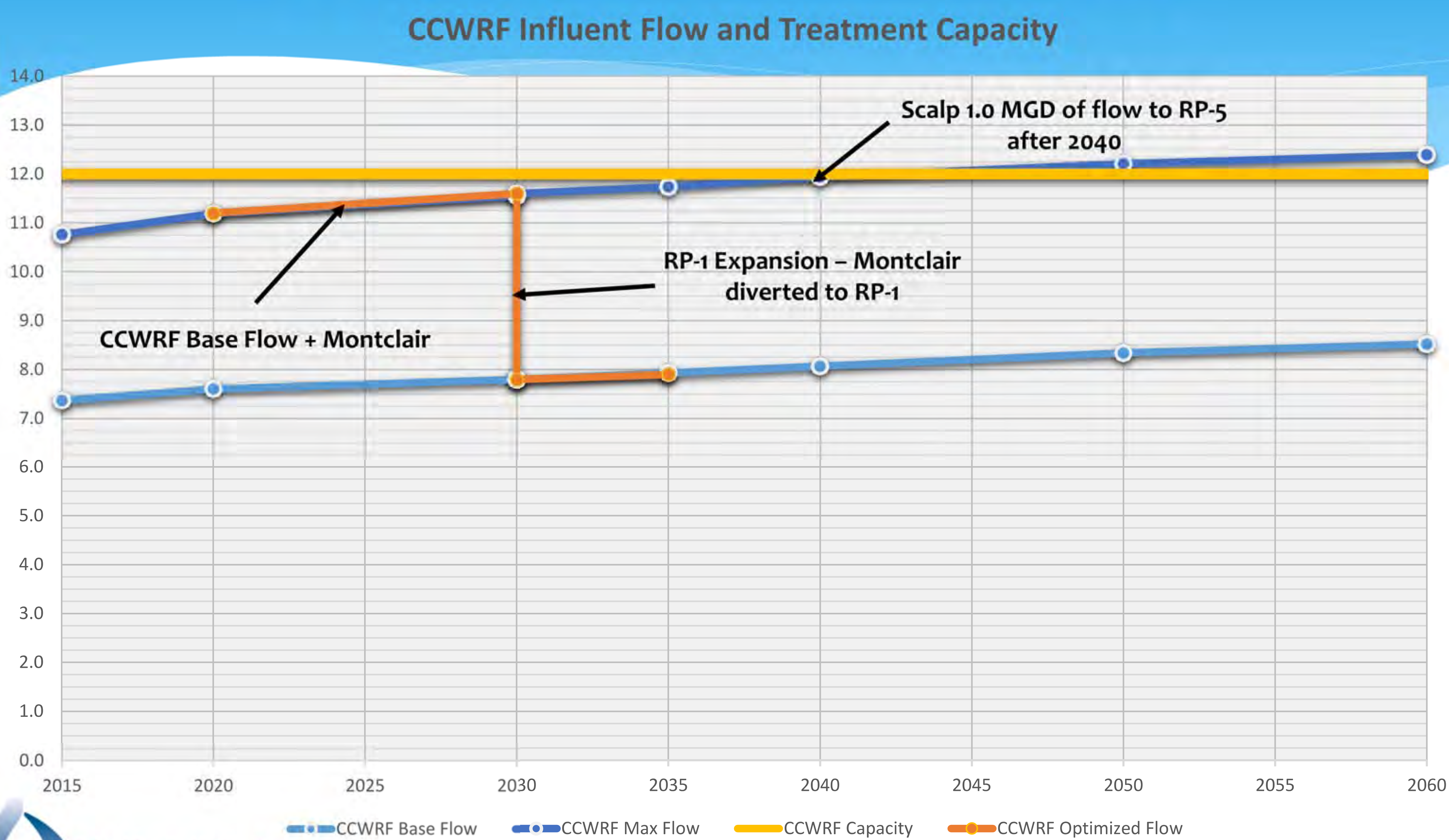


RP-1 Flow Forecast



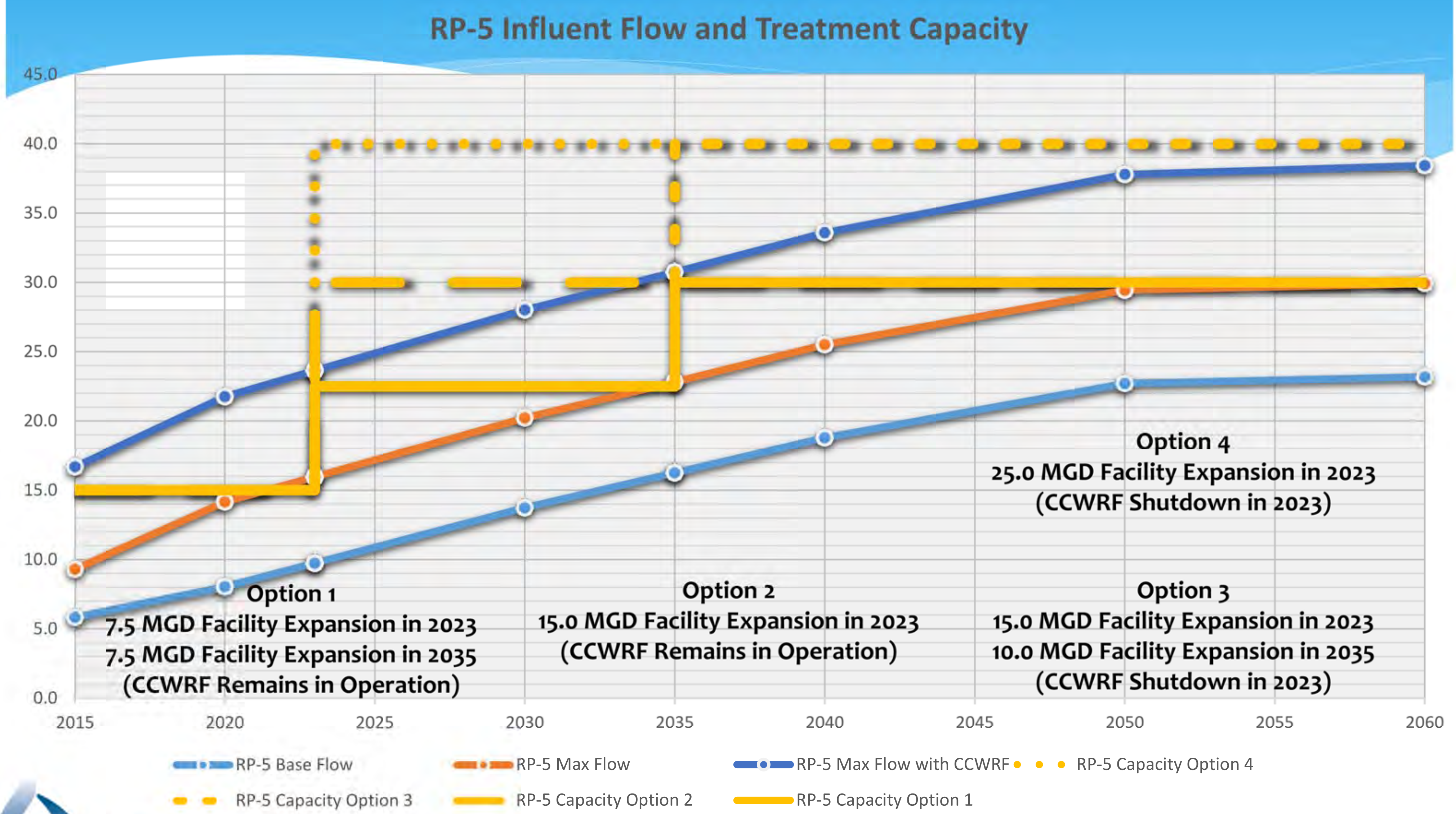
Inland Empire Utilities Agency
A MUNICIPAL WATER DISTRICT

CCWRF Flow Forecast



Inland Empire Utilities Agency
A MUNICIPAL WATER DISTRICT

RP-5 Flow Forecast



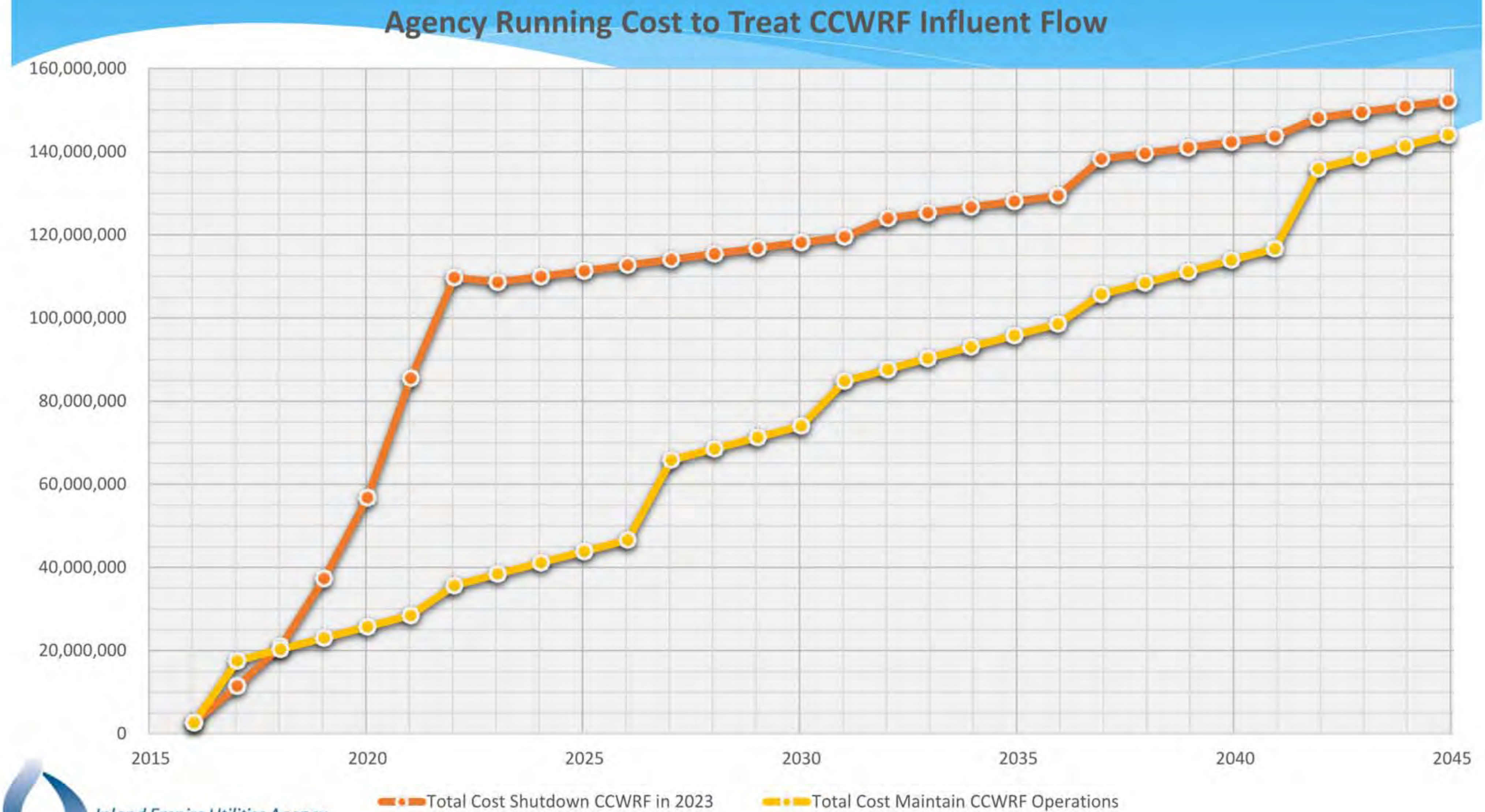
Inland Empire Utilities Agency
A MUNICIPAL WATER DISTRICT

CCWRF Decommissioning Alternatives

Alternative 1	• Maintain CCWRF Operation • NPV: $144.1 M
Alternative 2	• Shutdown CCWRF in 2033 • NPV: $169.2 M
Alternative 3	• Shutdown CCWRF in 2023 • NPV: $152.3 M

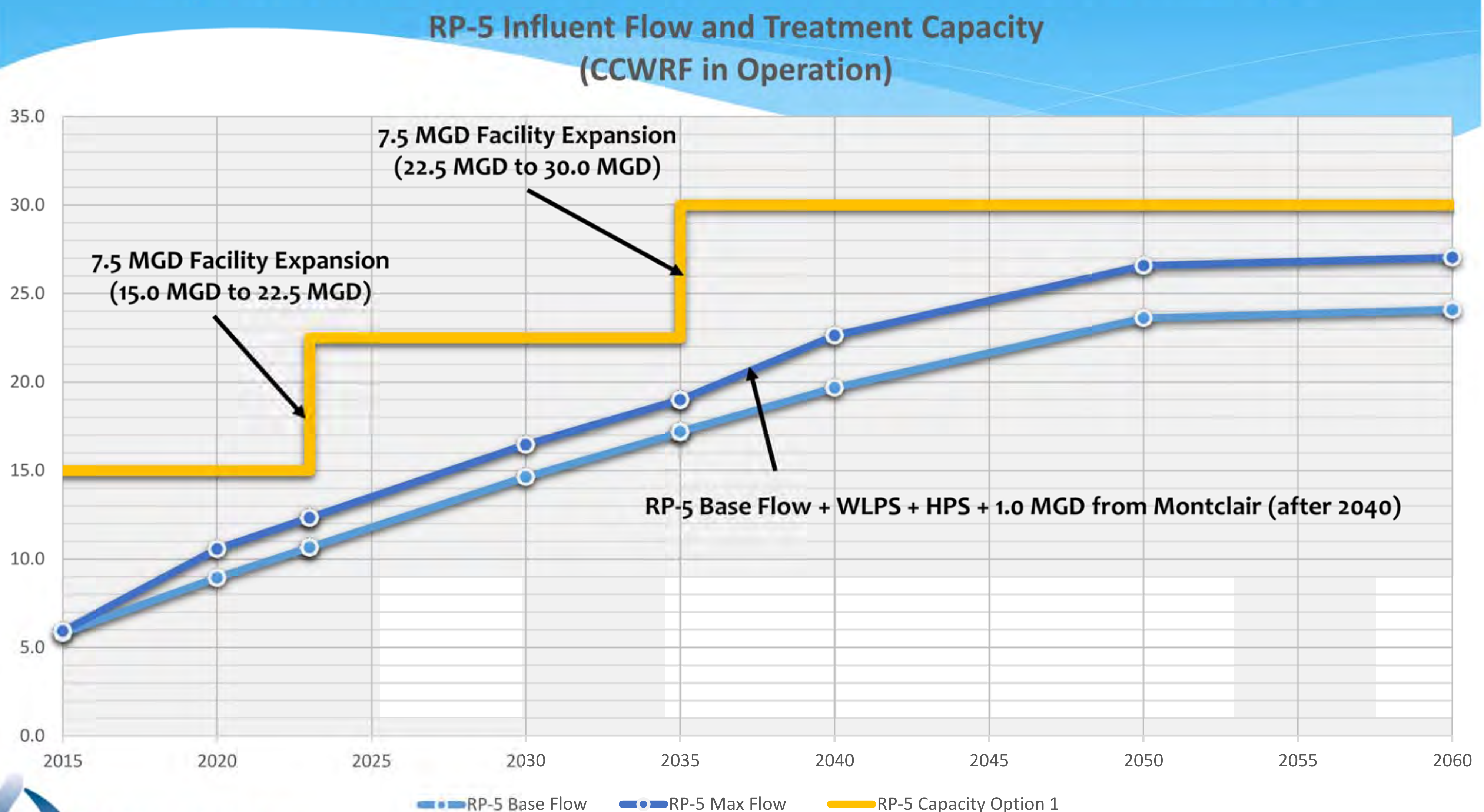
Inland Empire Utilities Agency
A MUNICIPAL WATER DISTRICT

CCWRF Influent Flow Treatment Cost



Inland Empire Utilities Agency
A MUNICIPAL WATER DISTRICT

RP-5 Flow Forecast (Maintain Operation of CCWRF)



Inland Empire Utilities Agency
A MUNICIPAL WATER DISTRICT

Proposed Facility Expansions (Tentative)

2018

RP-1 Expansion
- From 28.0 MGD to 32.0 MGD

2023

RP-5 Expansion
- From 15.0 MGD to 22.5 MGD

2030

RP-1 Expansion
- From 32.0 MGD to 40.0 MGD

2035

RP-5 Expansion
- From 22.5 MGD to 30.0 MGD

2040

RP-4 Expansion
- From 14.0 MGD to 21.0 MGD

RP-5 AND CCWRF SLUDGE QUANTITY ESTIMATES

Sludge production values were estimated on a per million gallons basis using the influent design pollutant concentrations decided upon on March 11, 2016. These influent design concentrations were chosen after analysis of five years of the existing plant data with consensus among Parsons and IEUA staff. These design concentrations are provided in Attachment 1 of this document. The design concentrations chosen were based on maximum month values. If the 90th percentile concentration was greater than the max month value, then the 90th percentile value was used.

These *max month* influent design concentrations were used to calculate the *max month* sludge production quantities (calculations provided in Attachment 2). Table 1 below presents the sludge quantity estimates. Parsons is recommending the sludge quantities used for design purposes should be the values calculated from the design influent concentrations (Table 1 columns 2 and 3) for two reasons:

1) The design values have already been agreed upon by IEUA staff after extensive analysis of 5 years of data; and
2) Sludge quantities calculated based on these values are realistic, representing years of experience of the Parsons team. For example, 70 percent removal of TSS in primary clarifiers (the chosen design value) is reasonable and in line with literature and our experience. Sludge yield used for secondary sludge calculations is in line with our experience for plants with similar SRT values in the range of 15 to 20 days.

Two important points should be recognized when considering the information presented in the table below. First, food waste and FOG have not been included in these sludge quantities and will need to be considered when the biosolids system is sized. Second, several peaking factors may be needed in the design of the biosolids system, including max day, max week, max 2-weeks, and max month. Not enough data were available to determine peaking factors to this level of precision. The peaking factors presented in Table 1 were determined by reviewing the available data as well as using the Parsons team engineering judgment, knowledge, and experience.

Suggested factors for solids train sizing:

1. Use max month average values for mesophilic digester sizing. For options that require shorter HRT, such as acid phase reactors, maximum day peaking factor may be used. Peaking Factor may be adjusted when the largest single unit of process is out of service for cleaning, repair, etc. Operational constraints must be considered such as not taking a digester down during peak loading periods or seasons.
2. Use a PF of 1.3 on the max month values for sizing of thickeners.
3. Use average annual values for O&M cost determination and BCE's.
4. For pumping sludges and pipe sizing, a PF of as high as 1.5 to 2.0 (not in the table) may be used. Primary and secondary sludge concentrations entering the thickening process will be in the range of 0.8 to 1 percent. Thickened sludge concentrations used for sizing the digesters should be no more than 5%, to account for variability in thickener performance.

RP-5 AND CCWRF SLUDGE QUANTITY ESTIMATES

Table 1: Sludge Quantity Estimates[a]

Parameter	RP-5 values based on design concentrations	CCWRF values based on design concentrations
Ultimate (year 2060) Projected Influent Flow (mgd)	30	8.5
Max Month Primary Sludge (lb/MG)	2335	2919
Max Month WAS (lb/MG)	1297	1633
Max Month Total Sludge (lb/MG)	3632	4552
Max Month Peaking Factor[b] (max month average/annual average)	1.4	1.4
Max 2-Weeks Peaking Factor[c] (max 2-weeks average/max month average)	1.2	1.2
Max Week Peaking Factor[c] (max week average/max month average)	1.25	1.25
Max Day Peaking Factor[b] (max day/max month average)	1.3	1.3
Annual Average Total Sludge (lb/MG)	2594	3251
Max Day Total Sludge (lb/MG)	4722	5918

[a] *FOG and food waste are not included in these sludge quantity estimates*

[b] *Based essentially on a review of existing plant data*

[c] *Not enough existing data to determine this precise peaking factor – value based on the judgment and experience of the Parsons team and interpolated from existing data*

ATTACHMENT 1: INFLUENT DATA – PROPOSED DESIGN VALUES

RP-1

Influent Design Concentrations:

tBOD = 600 mg/L *(for design, cBOD will be assumed to be 10% less than tBOD until more data is available)*

TSS = 550 mg/L

NH3-N = 40 mg/L

TKN = 65 mg/L

VSS/TSS = 0.85

Primary Treatment:

BOD Removal = 45%

TSS Removal = 65%

Peaking Factors:

Process peaking factor (for tankage) = 1.12 *(Max month average flow: annual average flow)*

Max Day Flow peaking factor (for filters and disinfection) = 1.30 *(Max day during max month: annual average)*

Aeration system load peaking factor = 1.25 *(Max day BOD load during the max month: Max month avg. BOD load)*

Hydraulic system peaking factor = 2.1 *(Maximum instantaneous flow: annual average flow)*

Centrate:

NH3-N = 1000 mg/L

COD = 850 mg/L

TSS = 250 mg/L

P = 120 mg/L

Annual Average Flow = 230 gpm; Max Month Average Flow = 260 gpm *(2014-2015 data)*

RP-5

Influent Design Concentrations:

BOD = 500 mg/L *(for design, cBOD will be assumed to be 10% less than tBOD until more data is available)*

TSS = 400 mg/L

NH3-N = 50 mg/L

TKN = 65 mg/L

VSS/TSS = 0.85

Primary Treatment:

BOD Removal = 45%

TSS Removal = 70%

Peaking Factors:

Process peaking factor (for tankage) = 1.18 *(Max month average flow: annual average flow)*

Max Day Flow peaking factor (for filters and disinfection) = 1.32 *(Max day during max month: annual average)*

Aeration system load peaking factor = 1.4 *(Max day BOD load during the max month: Max month avg. BOD load)*

Hydraulic system peaking factor = 3.0 *(Maximum instantaneous flow: annual average flow)*

RP-2 Centrate Concentrations:

NH3-N = 1000 mg/L

COD = 850 mg/L

TSS = 250 mg/L

P = 120 mg/L

CCWRF

Influent Design Concentrations:

BOD = 630 mg/L *(for design, cBOD will be assumed to be 10% less than tBOD until more data is available)*

TSS = 500 mg/L

NH3-N = 40 mg/L

TKN = 57 mg/L

VSS/TSS = 0.85

Peaking Factors:

Process peaking factor (for tankage) = 1.3 *(Max month average flow: annual average flow)*

Max Day Flow peaking factor (for filters and disinfection) = 1.35 *(Max day during max month: annual average)*

Aeration system load peaking factor = 1.3 *(Max day BOD load during the max month: Max month avg. BOD load)*

Hydraulic system peaking factor = 2.1 *(Maximum instantaneous flow: annual average flow)*

ATTACHMENT 2: SLUDGE QUANTITY ESTIMATES – CALCULATIONS

RP-5:

Design Influent BOD (max month average) = 500 mg/L
Design Influent TSS (max month average) = 400 mg/L
Design Primary BOD removal = 45%
Design Primary TSS removal = 70%
Design VSS/TSS = 0.85

Primary Sludge Estimate:

$$Primary\ Sludge = 400\,mg/L\ TSS \times 0.7 = 280\,mg/L\ TSS$$

$$\boxed{Primary\ Sludge\ (max\ month\ average) = 280\ mg/L\ TSS \times 8.34\ \frac{lb/MG}{mg/L} = 2335\frac{lb}{MG}}$$

WAS Estimate:

$$PE\ BOD = 500\ mg/L\ \times (1 - 0.45) = 275\ mg/L$$

$$Yield = 0.5\,mg\ VSS/mg\ BOD$$

$$nVSS = PE\ TSS\ \times \left(1 - \frac{VSS}{TSS}\right) = 120\ mg/L\ \times 0.15 = 18\ mg/L$$

$$WAS = PE\ BOD\ \times Yield + nVSS = 275\,mg/L \times 0.5 + 18\ mg/L = 155.5\frac{mg}{L}$$

$$\boxed{WAS\ (max\ month\ average) = 155.5\ mg/L\ \times 8.34\ \frac{lb/MG}{mg/L} = 1297\ lb/MG}$$

ATTACHMENT 2: SLUDGE QUANTITY ESTIMATES – CALCULATIONS

CCWRF:

Design Influent BOD (max month average) = 630 mg/L
Design Influent TSS (max month average) = 500 mg/L
Design Primary BOD removal (kept the same as RP-5) = 45%
Design Primary TSS removal (kept the same as RP-5) = 70%
Design VSS/TSS (kept the same as RP-5) = 0.85

Primary Sludge Estimate:

$$Primary\ Sludge = 500\,mg/L\ TSS \times 0.7 = 350\,mg/L\ TSS$$

$$\boxed{Primary\ Sludge\ (max\ month\ average) = 350\ mg/L\ TSS \times 8.34\,\frac{lb/MG}{mg/L} = 2919\,\frac{lb}{MG}}$$

WAS Estimate:

$$PE\ BOD = 630\ mg/L \times (1 - 0.45) = 346.5\ mg/L$$

$$Yield = 0.5\,mg\,VSS/mg\ BOD$$

$$nVSS = PE\ TSS \times \left(1 - \frac{VSS}{TSS}\right) = 150\ mg/L \times 0.15 = 22.5\ mg/L$$

$$WAS = PE\ BOD \times Yield + nVSS = 346.5\,mg/L \times 0.5 + 22.5\ mg/L = 195.75\,\frac{mg}{L}$$

$$\boxed{WAS\ (max\ month\ average) = 195.75\ mg/L \times 8.34\,\frac{lb/MG}{mg/L} = 1633\ lb/MG}$$

Inland Empire Utilities Agency
A MUNICIPAL WATER DISTRICT

Evaluation of RP-5 Food Waste Treatment System

Predesign Report
Volume III, Chapter 8

February 28, 2017

submitted by

PARSONS

in association with

Brown AND Caldwell

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 8: EVALUATION OF RP-5 FOOD WASTE TREATMENT SYSTEM

8.1 INTRODUCTION

8.1.1 Background

California has long been a pioneer in innovative and groundbreaking legislation to advance environmental protection. With the recent passing of State Assembly Bills (ABs) 341 and 1826 in California, the state is requiring diversion of solid waste streams away from landfills. One of those waste streams that needs to be diverted is organic waste, which includes food waste. Food waste is generated in many different types and forms, including expired food from groceries, food scraps from cafeterias, food scraps and expired food from residential homes, and waste products from industrial food processing plants. In California, anaerobic digestion at water resource recovery facilities is rapidly gaining momentum as the means to divert food waste from landfills, which will result in production of digester gas that can be used to generate power and recover heat. For these reasons, Inland Empire Utilities Agency (IEUA), together with Parsons as its consultant, would like to evaluate the best way to utilize the available food waste in the IEUA service area.

8.1.2 Regulatory and Environmental Drivers and Considerations

With the passing of AB 341, California established a goal of 75% diversion or reduction of solid waste by 2020. One of the facets of this overarching goal is the diversion of organic waste from landfills to composting or digestion facilities. This goal will reduce waste disposal loads at California landfills and will generate beneficial byproducts such as bio-fertilizer and/or biogas for renewable energy.

A subsequent assembly bill, AB 1826, provides the framework and tools to meet the organics recycling mandate of 75% reduction/diversion of waste from landfills. According to this bill, businesses, including public entities and multifamily complexes of 5 units or more are required to recycle organic waste if they produce:

- 8 cubic yards per week of organic waste as of 4/1/16
- 4 cubic yards per week of organic waste as of 1/1/17
- 4 cubic yards per week of solid waste as of 1/1/19

Organic waste includes the following:

- Food waste,
- Green waste,
- Landscape and pruning waste,
- Nonhazardous wood waste,
- And food-soiled paper waste

Prior to the above deadlines, every City/local jurisdiction is required to implement an organic waste recycling program. Cities must find alternative end-uses for organic waste. IEUA’s regional wastewater treatment plants can serve as potential solutions for recycling organic waste within its service area by treating organic waste along with biosolids generated at these plants. This will accomplish the following two beneficial goals:

1) Help cities within its service area to comply with AB 1826 and AB 341
2) Increase digester gas production and thereby additional renewable power generation towards energy self-sufficiency.

8.1.3 Current Practice at IEUA

Currently, IEUA is accepting some food waste for digestion and beneficial use at the Regional Water Recycling Plant #5 (RP-5) Solids Handling Facility (SHF), which is operated by Inland Bioenergy (IBE). Food waste delivered to SHF comes in three different forms:

1) Pre-Processed Slurry – this includes food waste (mostly fruits and vegetables) from grocery stores that are sent to the West Valley Material Recovery Facility (WVMRF) to be processed into a slurry prior to deliver to SHF via trucks.
2) Dissolved Air Flotation Thickener (DAFT) Sludge – this includes products such as expired coffee creamer that are sent to an off-site DAFT to be thickened before delivery to RP-5 SHF.
3) Liquid Food Waste – this includes syrups and other high-strength liquid waste products from industrial processing plants such as Coca-Cola.

Based on 2015 data from SHF, the current quantity of food waste being received is approximately 169 wet tons per day on average, or 41,000 gallons per day (gpd). The process flow at SHF is described below and is also shown in Figure 8-1.

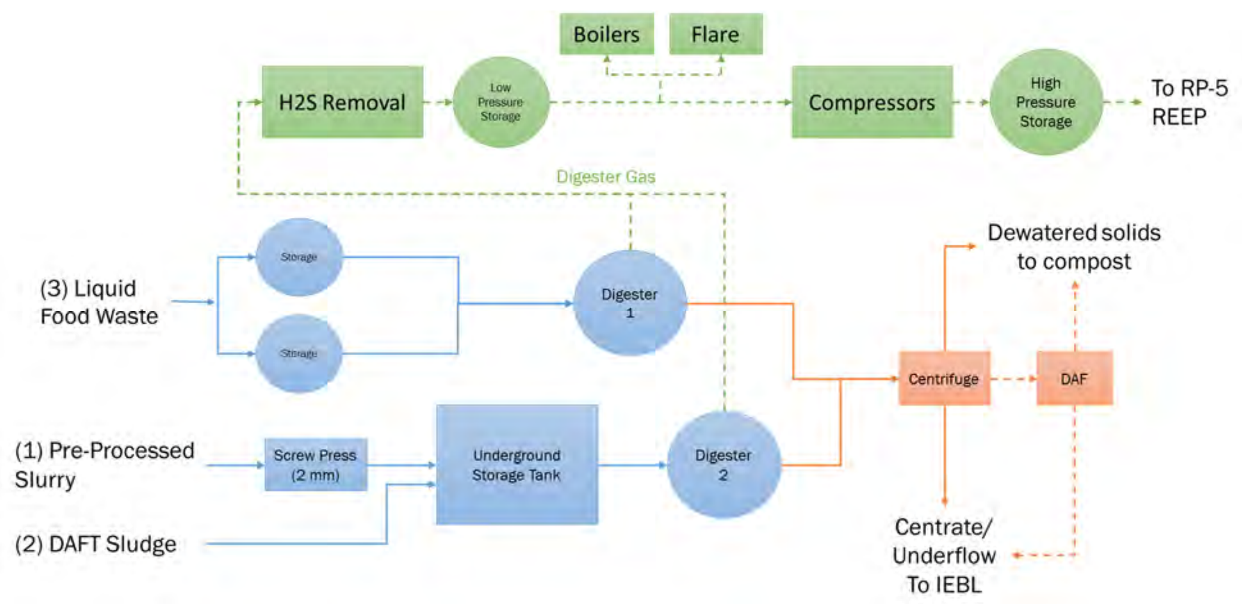


Figure 8-1: RP-5 SHF Process Flow Schematic

IBE operates two 1.2 million gallon (MG) digesters separately – one for "high solids" food waste including items (1) and (2) above with about 13% to 18% solids, and one for "low solids" food waste which consists of the liquid waste (item 3, about 2% to 3% solids). Liquid waste is fed to the "low solids" digester from two small storage tanks; the pre-processed slurry is sent to a 2-millimeter (mm) screw press and then mixed with the DAFT sludge in an underground storage tank before being fed to the "high-solids" digester. Digested sludge is then sent to a centrifuge and/or dissolved air flotation (DAF). Dewatered solids are sent to a composting facility and centrate (or underflow) is sent to the Inland Empire Brine Line (IEBL). Digester gas is sent to an iron sponge for hydrogen sulfide removal, then compressed for high-pressure gas storage before being sent to the internal combustion engines at RP-5 Renewable Energy Efficiency Project (REEP).

Current power production from the digester gas at SHF ranges between 800 kilowatts (kW) and 1,200 kW, based on 2015 data.

8.1.4 Food Waste and FOG Potential within IEUA's Service Area

IEUA has provided Parsons with a feasibility study report (draft dated June 2016) that analyzed the market-availability of food waste within IEUA's service area. CalRecycle data and population data of the seven cities within IEUA's service area (Chino, Chino Hills, Fontana, Montclair, Ontario, Rancho Cucamonga, and Upland) were used to estimate the quantity of food waste available for digestion. However, this study only estimated the quantity available until 2016, so Parsons extended the projections to 2060 based on population data from Southern California Association of Governments (SCAG).

The study's projections included two sources: residential and commercial food waste. Residential food waste comes from residential households in the service area while commercial food waste derives from large-scale commercial enterprises such as grocery stores, restaurants, and cafeterias. Through the course of Parsons' review of the study, the Agency has decided to exclude residential food waste from consideration for this pre-design report due to anticipated lack of regulatory enforcement and infrastructure for collection of residential food waste.

A separate report provided by IEUA (draft dated March 2016), estimated availability of Fat, Oil, and Grease (FOG) within the IEUA service area. This analysis for FOG availability extended to 2025, so Parsons projected these quantities to 2060 based on population growth data from SCAG. Commercial food waste and FOG projections are presented in Table 8-1 below.

Table 8-1: Market Available Quantities of Commercial Food Waste and FOG

	2016	2020	2025	2030	2035	2040	2045	2060
Commercial Food Waste Available (gal/day)	20,300	21,300	22,500	23,700	24,800	26,000	27,200	31,300
FOG Available (gal/day)	13,700	14,400	15,200	16,000	16,800	17,600	18,400	21,100
Total Food Waste & FOG Available	**34,000**	**35,700**	**37,700**	**39,700**	**41,600**	**43,600**	**45,600**	**52,400**

8.2 PRE-PROCESSED FOOD WASTE FROM IEUA'S SERVICE AREA

8.2.1 Engineered BioSlurry (EBS)

There are several methods of accepting food waste for co-digestion at WWTPs. One method is to accept all organic waste as is, process it onsite at the WWTP, and feed to the digesters. East Bay Municipal Utilities District (EBMUD) has a practice similar to this, and has experienced some process stability and operational issues. Another method is to source-separate the organic waste and process into a slurry, which is then trucked to the WWTP and fed directly to the digesters. This method is currently being practiced by Los Angeles County Sanitation Districts (LACSD) in a pilot program and they have not experienced any major issues thus far. LACSD wrote a specification for the bioslurry that must be met by waste haulers before it is accepted at the plant. This step provided predictability of the quality of food waste and eased concerns of potential digester upsets due to "bad" loads of food waste. IEUA and parsons staff visited the pilot plant at the Joint Water Pollution Control Plant (JWPCP) (owned by LACSD). Subsequently, IEUA has decided that food waste in the form of EBS should be pursued at RP-5 due to its simplicity and relatively fewer operational problems. IEUA will develop a specification similar to LACSD for food waste slurry to be accepted for co-digestion at RP-5.

8.2.2 Design Criteria – Quantity and Quality

Design criteria will be based on the food waste and FOG quantity projections described in Section 8.1.4. The relevant characteristics based on the LACSD specification as well as other literature sources for food waste and FOG are shown in Table 8-2 below. Design quantities for each were taken from Table 8-1, shown in Section 8.1.4.

Table 8-2: Design Quality of Food Waste and FOG

Parameter	Food Waste (EBS)	FOG
Total Solids (%)	14	6
Volatile Solids (% of TS)	85	90
Solids Volatile Solids Reduction (%)	-	95%
Gas Production (cu. ft./wet ton)	3,200	-

8.3 FOOD WASTE CO-DIGESTION: DEVELOPMENT OF ALTERNATIVES

The following three alternatives were developed in cooperation with the Agency and will be discussed in detail under this section.

1. Alternative 1: Base Case – Biosolids Only at RP-5
2. Alternative 2: Co-Digestion at RP-5
3. Alternative 3: Digestate from RP-5 SHF to RP-5

8.3.1 Alternative 1: Base Case – Biosolids Only at RP-5

8.3.1.1 Description of Alternative

Alternative 1 is the base case for biosolids treatment at RP-5, in which only the biosolids generated from the wastewater treatment process are treated; no food waste or FOG would be accepted at RP-5. This alternative was developed to provide a baseline for facilities, site layout, and costs. A schematic describing this alternative is presented in Figure 8-2 below.

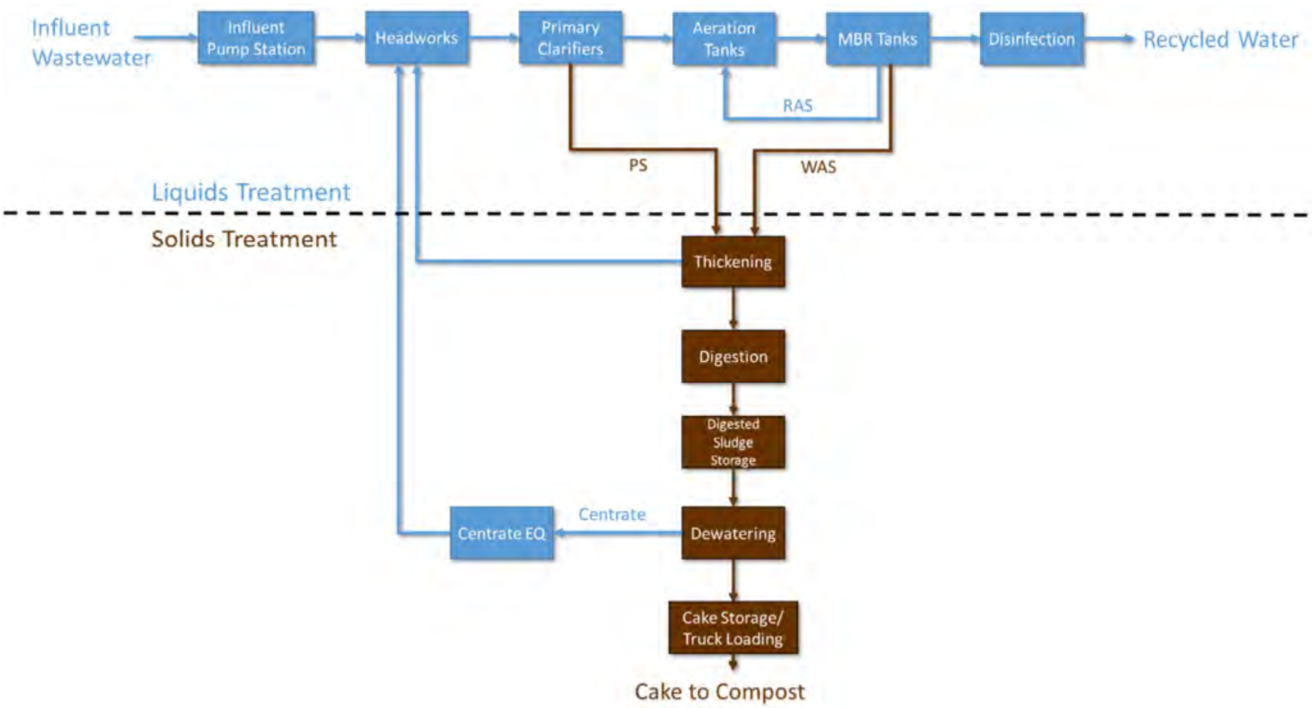


Figure 8-2: Alternative 1 Schematic

8.3.1.2 Design Criteria

Design criteria for Alternative 1 does not differ from the design criteria developed in *Chapter 7 – Solids Treatment Alternatives* because there will be no addition of food waste in this alternative.

8.3.1.3 Capital and O&M Costs

Costs for facilities required for 2035 as well as for the ultimate build-out period of 2060 were developed. The hinge point, when additional facilities or equipment are required, was between 2033 and 2036 for most processes; therefore 2035 was chosen as a representative hinge point. Capital costs for the 2035 and 2060 systems are presented below in Table 8-3.

Table 8-3: Alternative 1 Capital Costs*

	2035		2060	
System Components	**System Size**	**System Cost**	**System Size**	**System Cost**
Acid Phase Digestion	1 Acid (0.37 MG)	$3,041,000	2 Acid (0.4 MG)	$4,100,000
Gas Phase Digestion - Thermophilic/Mesophilic	3 Thermo (1.52 MG)	$19,287,000	5 Thermo (1.5 MG)	$28,500,000
Digested Sludge Storage/Backup Digester	1 Storage (1.52 MG)	$6,000,000	1 Storage (1.52 MG)	$6,000,000
Dewatering, Cake Storage, and Truck Loadout	3 centrifuges @ 300 gpm Cake storage, 2 x 5,500 ft^3	$24,400,000	4 centrifuges @ 300 gpm (4+1) Cake storage, 2 x 5,500 ft^3	$26,700,000
Centrate Handling	Centrate EQ tanks & pumps	$720,000	Centrate EQ tanks & pumps	$720,000
Digester Gas Conditioning at RP-5	H_2S & Siloxane Removal	$1,845,000	H_2S & Siloxane Removal	$1,845,000
Base Cost		$55,293,000		$67,865,000
Overhead & Profit, Inflation, Bonds & Insurances, Contingency (30%)		$36,000,000		$44,200,000
Total Biosolids Construction Cost		$91,300,000		$112,100,000
Design & Administration (20%)		$18,300,000		$22,400,000
Total Project Cost		**$109,600,000**		**$134,500,000**

**Note: only includes facilities that would be impacted by food waste*

Operations and maintenance (O&M) costs as well as potential savings from beneficial use of digester gas for the year 2045 (chosen as a midpoint) are presented below in Table 8-4.

Table 8-4: Alternative 1 – 2045 O&M Costs and Savings

Item	Cost
O&M – includes labor, power (includes parasitic loads), and chemicals	$7,454,000
Repair and replacement of equipment parts	$663,000
Savings - beneficial use of digester gas (power and heat)	($2,238,000)
Net Annual Costs	**$5,878,000**

8.3.2 Alternative 2: Co-Digestion at RP-5

8.3.2.1 Description of Alternative

In Alternative 2, food waste and FOG would be received at RP-5 for co-digestion. Both food waste and FOG would be received at an onsite receiving station, then pumped directly to the digesters for co-digestion. This process is shown below in Figure 8-3.

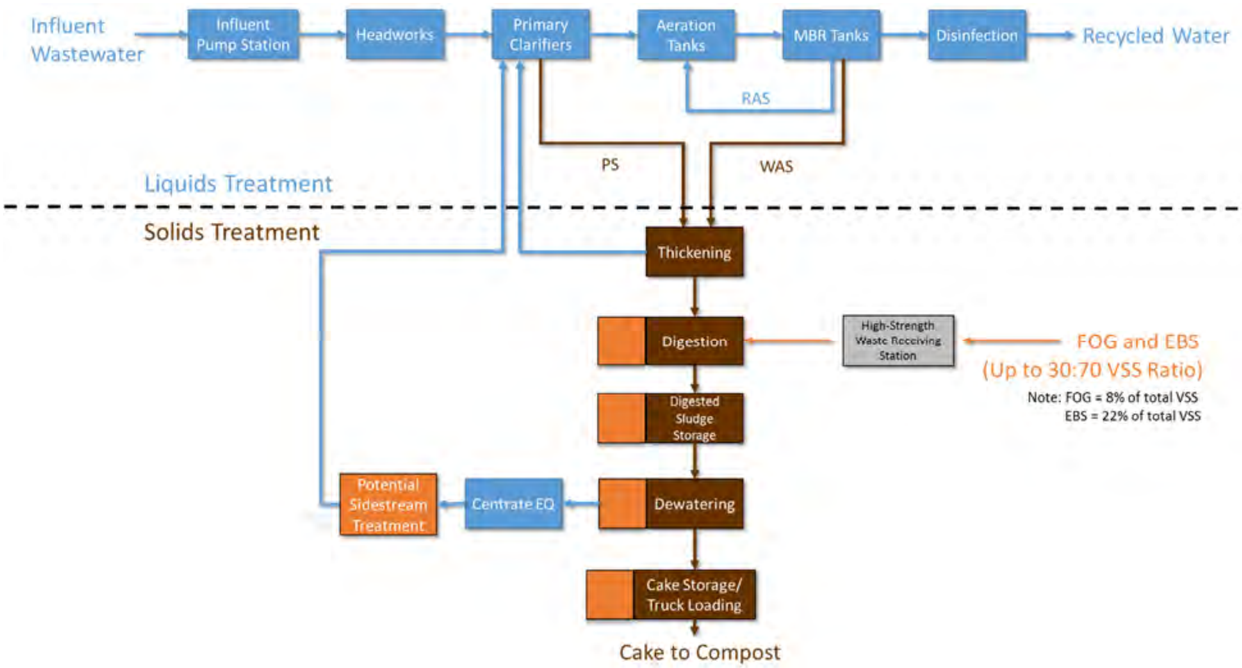


Figure 8-3: Alternative 2 Schematic

As shown in the above figure, food waste and FOG receiving station is required at RP-5 under this alternative. Preliminary process schematics for the food waste portion and FOG portion of the receiving station are shown in Figures 8-4 and 8-5, respectively. While the equipment required for the receiving station is slightly different between the two (i.e. heat exchangers are only required for the FOG portion), the receiving station would be combined in one central location. The planned location of the food waste and FOG receiving station in relation to the other solids handling processes is shown in Figure 8-6.

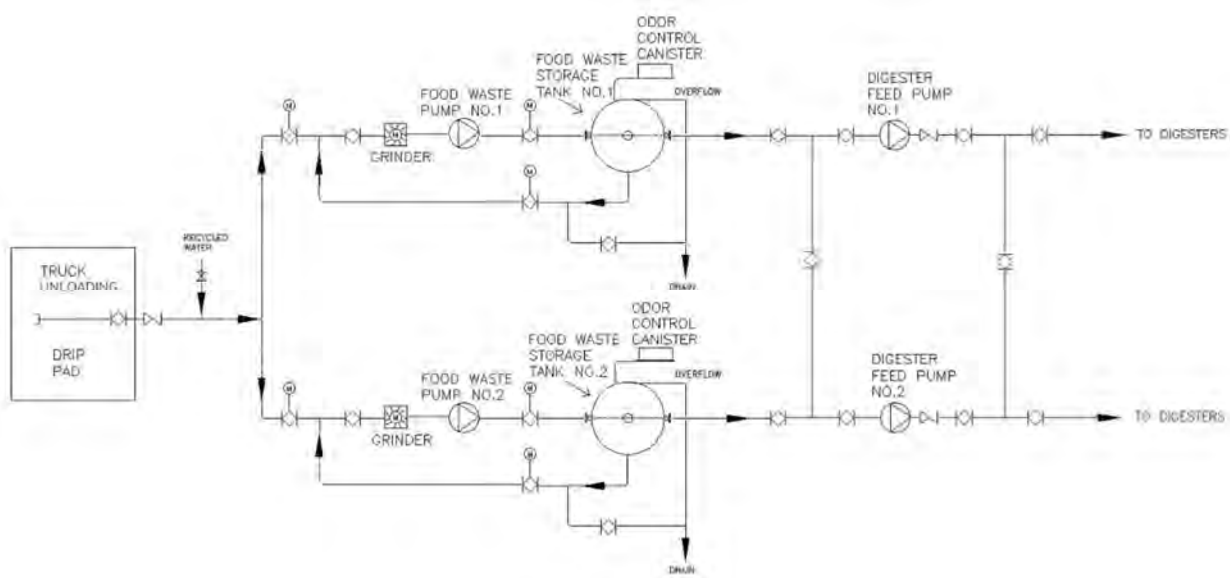


Figure 8-4: Food Waste Receiving Station Preliminary Process Schematic

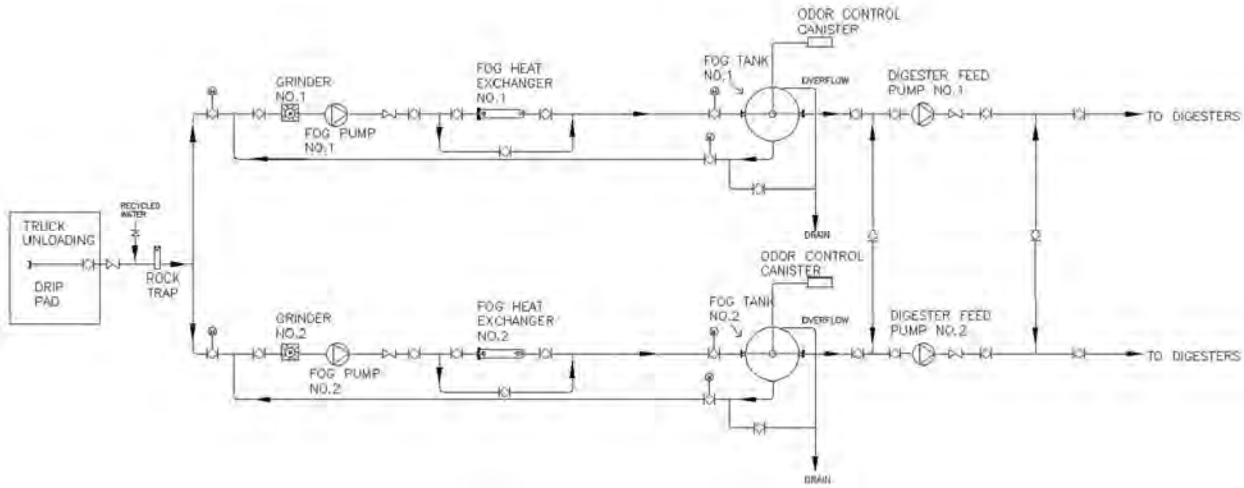


Figure 8-5: FOG Receiving Station Preliminary Process Schematic

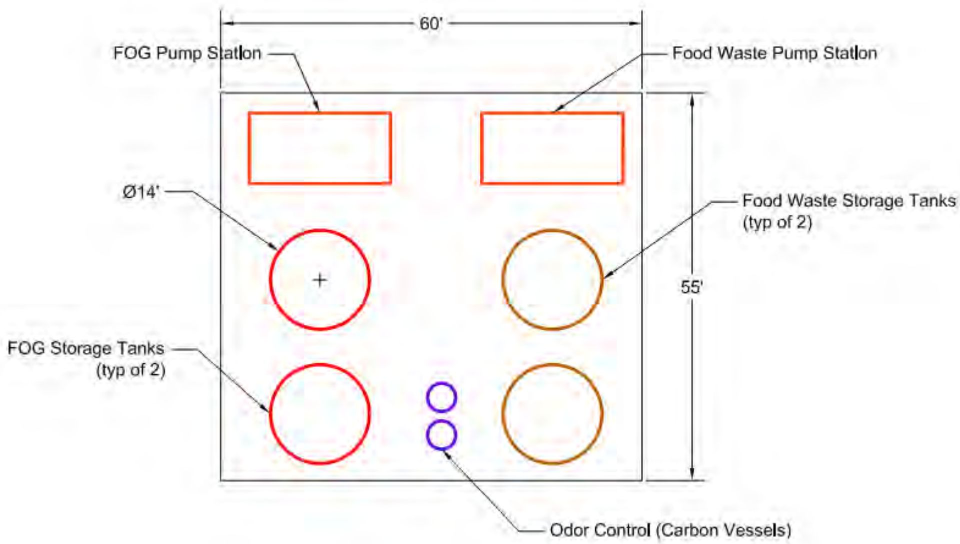


Figure 8-6: Preliminary Layout for Food Waste and FOG Receiving Station

8.3.2.2 Design Criteria

The amount of food waste and FOG that can be accepted into the digestion system at RP-5 is limited by the organic solids ratio between food waste and biosolids. To maintain reliability in the digestion process and maximize gas production, previous studies and operating data at other facilities indicate that food waste and FOG should only be co-digested up to 30% of the total volatile solids (VS) load, resulting in a 30:70 ratio of food waste/FOG VS to biosolids VS.

Therefore, the amount of food waste and FOG that can be co-digested at RP-5 is tied to the biosolids projections that were presented in Chapter 7. The quantity of organic waste for co-digestion thus calculated is slightly below the market-available quantity of food waste and FOG. In this analysis, Parsons assumed that all the market-available FOG would be accepted at RP-5 due to its high volatility and substantial benefit to gas production. The remaining portion of the capacity for organic waste up to the 30:70 ratio would consist of EBS. The quantities of food waste and FOG estimated for co-digestion are shown below in Table 8-5.

Table 8-5: Food Waste and FOG Co-Digestion Design Quantities

	2025	2030	2035	2040	2045	2050	2055	2060
FOG VS (lb/day)	6,848	7,206	7,549	7,907	8,283	8,676	9,088	9,520
Food Waste VS (lb/day)	17,593	21,497	23,764	26,231	27,986	29,432	29,427	29,407
Total Food Waste/FOG VS (lb/day)	**24,442**	**28,703**	**31,313**	**34,138**	**36,269**	**38,108**	**38,516**	**38,927**
FOG Quantity (gpd)	15,207	16,001	16,761	17,557	18,391	19,265	20,180	21,138
Food Waste Quantity (gpd)	17,727	21,660	23,945	26,430	28,199	29,656	29,651	29,631
Total Food Waste/FOG Quantity (gpd)	**32,933**	**37,661**	**40,706**	**43,988**	**46,590**	**48,921**	**49,831**	**50,769**

8.3.2.3 Capital and O&M Costs

Similar to Alternative 1, costs were developed for facilities required to reach the 2035 capacity and the 2060 capacity for Alternative 2. These costs are presented below in Table 8-6.

Table 8-6: Alternative 2 Capital Costs*

	2035		2060	
System Components	**System Size**	**System Cost**	**System Size**	**System Cost**
Acid Phase Digestion	1 Acid (0.37 MG)	$3,041,000	2 Acid (0.4 MG)	$4,100,000
Gas Phase Digestion - Thermophilic/Mesophilic	4 Thermo (1.52 MG)	$23,900,000	6 Thermo (1.5 MG)	$33,100,000
Digested Sludge Storage/Backup Digester	1 Storage (1.52 MG)	$6,000,000	1 Storage (1.52 MG)	$6,000,000
Dewatering, Cake Storage, and Truck Loadout	4 centrifuges @ 300 gpm Cake storage, 2 x 6,000 ft^3	$27,450,000	5 centrifuges @ 300 gpm (4+1) Cake storage, 2 x 6,000 ft^3	$29,750,000
Centrate Handling	Centrate EQ tanks & pumps	$800,000	Centrate EQ tanks & pumps	$800,000
Digester Gas Conditioning at RP-5	H_2S & Siloxane Removal	$1,845,000	H_2S & Siloxane Removal	$1,845,000
HSW Receiving Station	~50,000 gal/day of pre-processed slurry	$2,000,000	~50,000 gal/day of pre-processed slurry	$2,000,000
Base Cost		**$65,036,000**		**$77,595,000**
Overhead & Profit, Inflation, Bonds & Insurances, Contingency (30%)		$42,300,000		$50,500,000
Total Construction Cost		**$107,300,000**		**$128,100,000**
Design & Administration (20%)		$21,500,000		$25,600,000
Total Project Cost		**$128,800,000**		**$153,700,000**

**Note: only includes facilities that would be impacted by food waste*

O&M costs and savings from beneficial use of digester gas for Alternative 2 are provided in Table 8-7 below.

Table 8-7: Alternative 2 – 2045 O&M Costs and Savings

Item	Cost
O&M – includes labor, power (includes parasitic loads), and chemicals	$9,230,000
Repair and replacement of equipment parts	$710,000
Savings - beneficial use of digester gas (power and heat)	($3,900,000)
Net Annual Cost	**$6,040,000**

8.3.3 Alternative 3: Digestate from RP-5 SHF to RP-5

8.3.3.1 Description of Alternative

This alternative considers that all food waste and FOG are accepted at SHF for digestion, and all digestate from SHF will be sent to the RP-5 digesters. Currently, digestate at SHF is dewatered and the centrate is sent to the IEBL. By proposing to send centrate to RP-5 instead of discharging to IEBL, the SHF benefits from avoided centrate disposal fees as well as an option not to operate capacity-limited digestate dewatering processes (existing centrifuge and DAF at SHF).

In light of the above benefits, IBE would like to send digestate produced at SHF to RP-5. The digestate can either be sent to the digesters or to the digested sludge holding tank for dewatering. The goal of sending the digestate to the digesters would be to increase gas production. However, after technical review and discussions with food waste digestion experts, Parsons recommends sending the digestate downstream of the digesters because there is very little gas that can be generated from the digestate that has been fully digested already. This analysis considers the digestate being sent to the digested sludge holding tank at RP-5 because the gas production potential of the digestate from SHF is minimal. A schematic describing this alternative is shown in Figure 8-7.

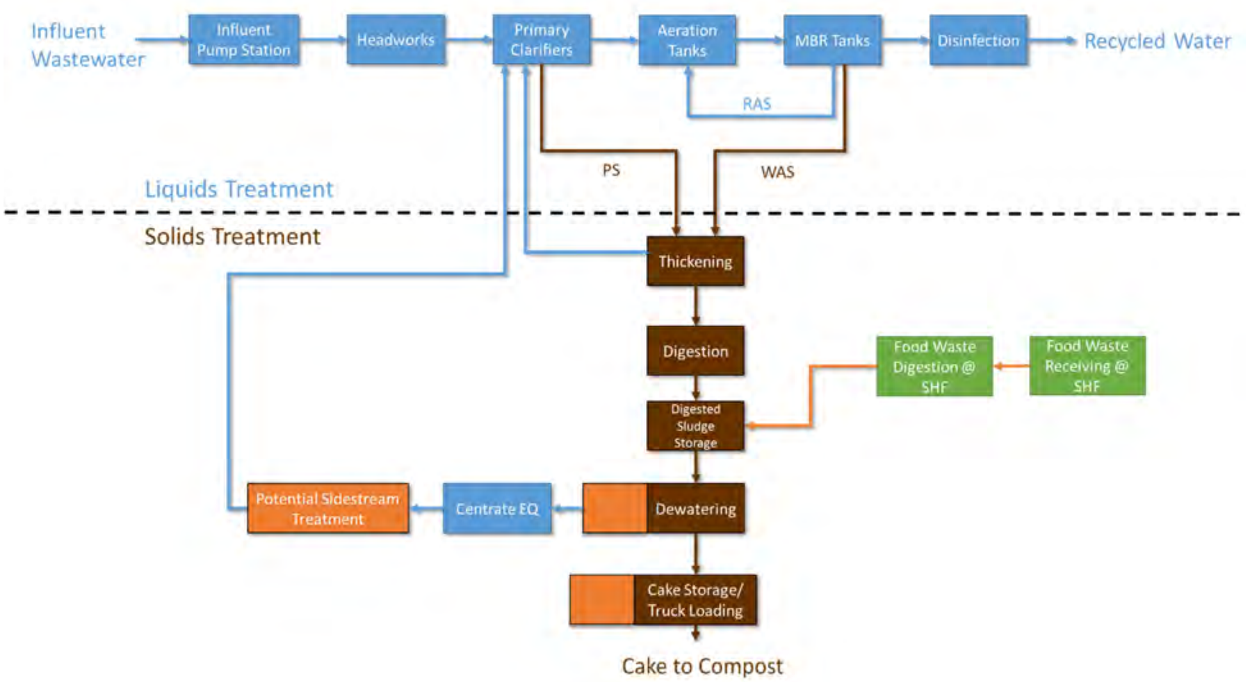


Figure 8-7: Alternative 3 Schematic

8.3.3.2 Design Criteria

As stated in the previous section, this alternative considers all food waste being sent to SHF and all digestate being sent to dewatering at RP-5. No reliable data was available with projections for industrial food waste currently being received at SHF, so this quantity was assumed to remain constant from now until 2060. The food waste quantity projections are shown in Table 8-8 below.

Table 8-8: Food Waste/Digestate Quantity Projections

	2025	2030	2035	2040	2045	2060
Pre-Processed Slurry (gal/day)	22,500	23,700	24,800	26,000	27,200	31,300
FOG (gal/day)	15,200	16,000	16,800	17,600	18,400	21,100
Industrial (gal/day)	40,500	40,500	40,500	40,500	40,500	40,500
Total digester feed (gal/day)	78,000	80,000	82,000	84,000	86,000	93,000
Total Digestate (gal/day)	**78,000**	**80,000**	**82,000**	**84,000**	**86,000**	**93,000**

Note: Based on discussions with the Agency, FOG may not be received at SHF. For design purposes, approximately 50,000 gallons/day of pre-processed slurry in 2060 is considered.

8.3.3.3 Capital and O&M Costs

The capital costs for Alternative 3 for a 2035 and a 2060 system are presented in Table 8-9 below.

Table 8-9: Alternative 3 Capital Costs*

	2035		2060	
System Components	**System Size**	**System Cost**	**System Size**	**System Cost**
Acid Phase Digestion	1 Acid (0.37 MG)	$3,041,000	2 Acid (0.4 MG)	$4,100,000
Gas Phase Digestion - Thermophilic/Mesophilic	3 Thermo (1.52 MG)	$19,287,000	5 Thermo (1.5 MG)	$28,500,000
Digested Sludge Storage/Backup Digester	1 Storage (1.52 MG)	$6,000,000	1 Storage (1.52 MG)	$6,000,000
Dewatering, Cake Storage, and Truck Loadout	4 centrifuges @ 300 gpm Cake storage, 2 x 6,000 ft^3 (SHF centrifuge below)	$27,450,000	5 centrifuges @ 300 gpm (5+1) Cake storage, 2 x 6,000 ft^3	$29,750,000
Centrate Handling	Centrate EQ tanks & pumps	$800,000	Centrate EQ tanks & pumps	$800,000
Digester Gas Conditioning at RP-5	H_2S & Siloxane Removal	$1,845,000	H_2S & Siloxane Removal	$1,845,000
HSW Receiving Station at SHF	~50,000 gal/day of pre-processed slurry	$2,000,000	~50,000 gal/day of pre-processed slurry	$2,000,000
Transfer Pumps & Piping from SHF to Digested Sludge Storage		$296,000		$296,000
RP-5 SHF Digester Gas Conditioning		$654,000		$654,000
Base Cost		**$61,373,000**		**$73,945,000**
Overhead & Profit, Inflation, Bonds & Insurances, Contingency (30%)		$40,000,000		$48,100,000
Total Construction Cost		**$101,400,000**		**$122,000,000**
Design & Administration (20%)		$20,300,000		$24,400,000
Total Project Cost		**$121,700,000**		**$146,400,000**

**Note: only includes facilities that would be impacted by food waste*

The 2045 O&M costs and savings from beneficial use of digester gas for Alternative 3 are presented below in Table 8-10.

Table 8-10: Alternative 3 – 2045 O&M Costs and Savings

Item	Cost
O&M – includes labor, power (includes parasitic loads), and chemicals	$9,870,000
Repair and replacement of equipment parts	$830,000
Savings – beneficial use of digester gas (power and heat)	($3,400,000)
Savings – Diversion of IEBL Discharge	($400,000)
Net Annual Cost	**$6,900,000**

8.4 IMPACT OF FOOD WASTE ON TREATMENT PROCESSES AT RP-5

Accepting food waste at RP-5, whether it is food waste slurry for co-digestion or digestate from SHF, will have impacts on the liquid treatment processes at RP-5. For Alternatives 2 and 3, the ammonia concentration in the centrate will increase significantly compared to centrate from the treatment of biosolids only in case of Alternative 1. Based on over a year worth of data on centrate at SHF, the max month ammonia concentration was determined to be approximately 500 milligrams/liter (mg/L). The current practice at SHF is to discharge centrate to IEBL, which will remain as an option for centrate disposal at RP-5. However, it is the Agency's preference to minimize discharges to IEBL thereby realizing savings on disposal fees. Therefore, the following two options for treating centrate are considered and discussed in detail in this section:

1. Send centrate to RP-5 headworks and treat increased ammonia load in secondary treatment.
2. Sidestream treatment process for centrate (DEMON).

Centrate treatment options are discussed in more detail in *Volume I, Chapter 5/Volume II Chapter 6 – Evaluation of Onsite Centrate Treatment and Offsite Recycle Flow Discharge*.

8.4.1 Option 1: Treat centrate in liquid stream processes

The centrate from food waste will increase the overall ammonia load on the RP-5 secondary treatment system, resulting in increased air demand and requirement for supplemental carbon (methanol). For this analysis, an ammonia concentration of 500 mg/L in food waste centrate was used based on the 92nd percentile ammonia concentration in the centrate at SHF. Based on this concentration and the projected food waste quantities, the ammonia load at RP-5 would increase by approximately 6% by accepting food waste centrate (shown in Figure 8-8 below). BioWin^{TM} was used to model the RP-5 secondary treatment system with the increased ammonia load. The modeling results indicated that the proposed secondary system (MBR retrofit, described in *Vol II, Chapter 7*) can handle the increased ammonia load but will require methanol addition during periods where the BOD:TKN ratio drops below 3.6:1. With max month TKN loads and annual average BOD loads, BioWin^{TM} predicted a required methanol usage of 1000 gpd. Methanol injection is described in more detail in *Vol II, Chapter 7*.

8.4.2 Option 2: Sidestream Centrate Treatment (DEMON)

The driver for sidestream centrate treatment is the cost of methanol addition and increased power demand for aeration. However, there is a high capital expenditure required to construct a sidestream treatment process such as DEMON. Additionally, installing sidestream centrate treatment requires operators to learn how to operate a new process and will require additional time, energy, and maintenance. Based on preliminary analysis, the methanol requirement in Option 2 would need to be as high as approximately 1,800 gpd to make sidestream treatment more cost-effective.

8.4.3 Recommendations for Handling Increased Ammonia Load

Parsons team recommends treating the increased ammonia load from the food waste/digestate centrate in the secondary treatment system. The cost of methanol required is not enough to justify construction of a sidestream treatment process.

8.5 BUSINESS CASE EVALUATION (BCE)

The BCE results are presented in Table 8-11 below for the *2060 ultimate costs* for Alternatives 1, 2, and 3 (for processes impacted by food waste only). The full BCE spreadsheets are attached in Exhibit I of this Volume. It is important to note that the benefits of combined heat and power (CHP) were capped to 3-megawatt (MW) production due to the current capacity of the RP-5 REEP engines. Any gas produced that cannot be utilized in the engines can be used in the boilers or in a future renewable gas utilization facility, such as CNG or RNG.

Table 8-11: Food Waste Alternatives BCE Results

Inland Empire
UTILITIES AGENCY

		Results ($000s)		
Agency:	Inland Empire Utilities Agency	Capital Cost	30-year NPV	Benefit over 'Do Nothing'
Project/Problem:				
Alternative 1	**FW Alt 1**	$134,500,000	($283,824,619)	
Alternative 2	**FW Alt 2**	$153,700,000	($303,508,513)	($19,683,894)
Alternative 3	**FW Alt 3**	$146,400,000	($331,463,251)	($47,638,632)
Alternative 4				
Alternative 5				
Alternative 6				
Alternative 7				
Alternative 8				
Alternative 9				
Alternative 10				
Alternative 11				
Alternative 12				

Year of analysis:	2016
Escalation rate:	3.00%
Discount rate:	2.00%

8.6 CONCLUSIONS AND RECOMMENDATIONS

While Alternative 1 provides the lowest cost alternative, the Agency would like to be able to accept all of the food waste digestate from SHF, providing the following benefits:

- Elimination of dewatering facilities at SHF
- Avoidance of costs associated with disposing of SHF centrate to IEBL
- Economies of scale associated with dewatering both digested solids streams together (food waste digestate from SHF and biosolids digestate from RP-5)

The Agency's goal is to construct some of the facilities required to handle food waste, while minimizing the capital expenditure. Additionally, the project construction can be phased to further reduce costs. Upon review of the alternatives, the Parsons team recommends Alternative 3, which consists of receiving and digesting food waste at RP-5 SHF and sending digestate to digested sludge storage and dewatering at RP-5. The cost for the recommended system falls in-between the capital costs for Alternatives 1 and 2.

Some key features to note include the following:

- 50,000-gpd receiving station at RP-5 SHF included for pre-processed food waste slurry

- Thickening for 2035 biosolids quantity – an additional RDT can be added in 2035 if needed
- 5 digesters required for 2035 biosolids quantity; equipment is provided to convert these digesters to thermophilic; two digesters will be capable of digested sludge storage
- Dewatering provided for 2035 biosolids quantity plus digestate from SHF; an additional centrifuge can be added in 2035 if needed
- Cake storage provided to accommodate increased cake from SHF digestate
- Recommended to only provide centrate equalization tanks and pumps (rather than sidestream centrate treatment) and methanol injection system
- No digester gas storage recommended. Fluctuations in digester gas production from RP-5 can be balanced by varying the gas flow from SHF. There are existing low- and high-pressure storage vessels for the SHF gas, which can be used to control gas flow. In later years, gas storage can be added to maximize energy production.
- Digester gas conditioning provided for RP-5 biogas and RP-5 SHF gas
- Use existing internal combustion engines and expand REEP in the future or explore other beneficial use of excess gas

Inland Empire Utilities Agency
A MUNICIPAL WATER DISTRICT

Evaluation of Beneficial Use Of RP-5 Digester Gas

Predesign Report
Volume III, Chapter 9

February 28, 2017

submitted by

PARSONS

in association with

Brown AND Caldwell

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 9: EVALUATION OF BENEFICIAL USE OF RP-5 DIGESTER GAS

9.1 INTRODUCTION

9.1.1 Background and Purpose

In order to develop the basic framework of alternatives for digester gas utilization, gas production from the Regional Water Recycling Plant #5 (RP-5), RP-1, and RP-5 Solids Handling Facility (SHF) was investigated. The purpose of this chapter is to describe existing and potential digester gas sources, and provide recommendations for beneficial use of digester gas at RP-5. This chapter also includes a preliminary evaluation of improvements to the existing 1.5-megawatt (MW) engines at RP-5 Renewable Energy Efficiency Project (REEP) to meet new emission standards, per South Coast Air Quality Management District (SCAQMD).

9.1.2 Description of Current Sources of Digester Gas

Three main sources of digester gas are being considered for the analysis presented in this chapter – gas from RP-5 (digestion of municipal biosolids only), gas from RP-1 (digestion of municipal biosolids only) and gas from RP-5 SHF (digestion of food waste and fat, oil, and grease [FOG]). Because the gas from RP-5 SHF will be from dedicated digestion of food waste/FOG, the gas produced is expected to free of siloxanes and requires only hydrogen sulfide (H_2S) removal. Gas from RP-1 and RP-5 will require siloxane removal in addition to H_2S removal due to the digestion of municipal biosolids. These potential digester gas sources and the 2060 projected gas quantities are shown below in Figure 9-1.

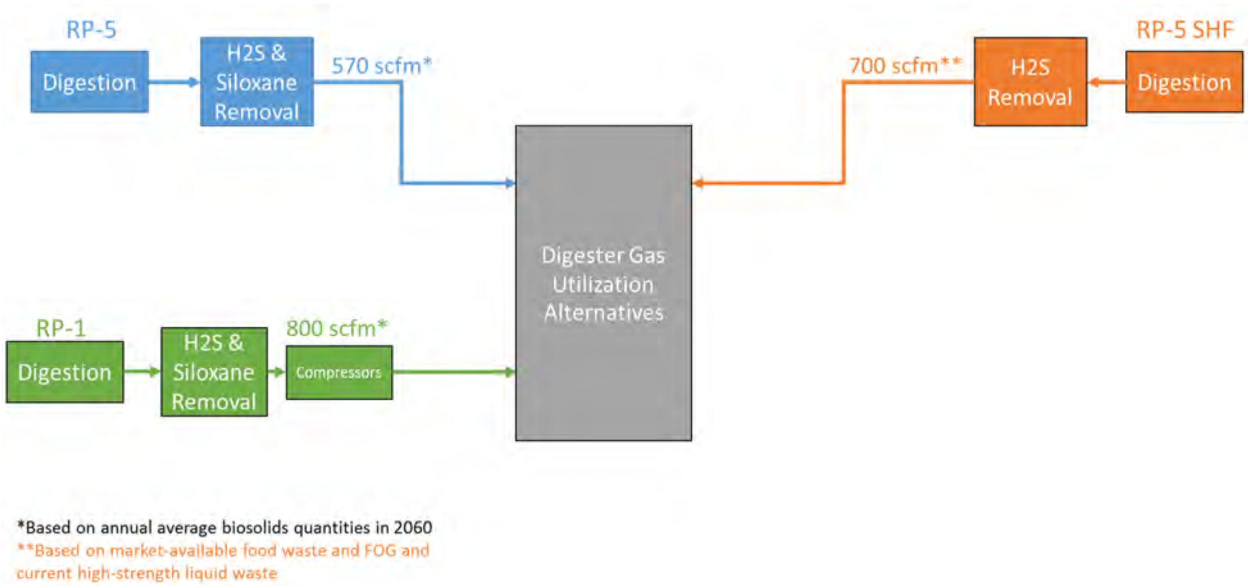


Figure 9-1: Sources of Digester Gas

9.1.3 Description of Existing REEP Facility and Solids Handling Facility

Digester gas produced from the two dedicated food waste digesters at RP-5 SHF is sent to two iron sponge vessels to reduce H_2S concentration. Digester gas is then boosted through low-pressure storage units prior to gas compression and high-pressure storage. Currently, the SHF digesters are producing about 260 standard cubic feet per minute (scfm) of digester gas (annual average). Not all gas from RP-5 SHF is sent to the RP-5 REEP; a portion of the gas is sent to the SHF boilers for digester heating and excess gas is flared.

The cogeneration facility at RP-5 is currently leased to a third party, Inland Bioenergy (IBE). This facility utilizes digester gas from the RP-5 SHF to generate electricity via two 1.5-MW Caterpillar internal combustion engines as shown in Figure 9-2, operating at approximately 1 MW output (currently only operating one engine at a time) on an average. There are two additional concrete pads inside the REEP building for installing future engines. However, Pad No. 4 is reportedly too close to the equipment near the stairway going to the mezzanine floor; hence, only one engine may be installed in the future. These concrete pads are built to be demolished easily in case the future engine needs a different size of concrete pad for installation. There is a natural gas blending tank installed at the REEP facility, but it is not currently used to supplement digester gas. All the power produced is primarily used to meet the on-site power demand at RP-5. The facility is enrolled in a Net Energy Metering (NEM) agreement with Southern California Edison (SCE) for exporting any excess power back to the grid.

Figure 9-2: One of Two Existing Caterpillar Internal Combustion Engines

The major components of the cogeneration system include engine generators, exhaust heat recovery system, an organic Rankine cycle (ORC) system designed to generate 200 kilowatts (kW) of power from exhaust heat, and an absorption chiller system. Currently, the heat recovery system, including ORC and absorption chiller system, are not in use. A new electric chiller system has been recently installed to meet the cooling loads for the Agency's Headquarters (HQ) Buildings A and B.

9.2 REGULATORY AND ENVIRONMENTAL DRIVERS AND CONSIDERATIONS

There are various regulatory and environmental drivers and considerations that need to be evaluated in the digester gas beneficial use analysis. For the alternatives geared towards cogeneration, regulations must be met to comply with emission standards for the specific cogeneration technology being considered. SCAQMD rule 1110.2 stipulates the emission limits for nitrogen oxides (NOx), Volatile Organic Compounds (VOCs) and Carbon Monoxide (CO) from internal combustion engines. These emission limits are considered to be quite stringent and would most likely require catalytic exhaust treatment, such as Selective Catalytic Reducers (SCRs) and/or oxidation catalysts (OxiCat). For the alternatives focused on generating renewable fuel, such as Renewable Natural Gas (RNG) for pipeline injection or producing Compressed Natural Gas (CNG) for vehicular fuel, regulations play a crucial role as they also provide the desired incentives to make these alternatives more economically feasible.

9.3 DIGESTER GAS GENERATION POTENTIAL

9.3.1 Digester Gas Estimates

Digester gas from each of the three sources listed above has been estimated and projected until the buildout year of 2060. For RP-5 and RP-1, these estimates are based on the biosolids quantity projections presented in Volume III, Chapter 7 (RP-5) and Volume I, Chapter 7 (RP-1) along with an assumed volatile solids reduction (VSR) achieved in the digesters (60%) and gas production ratio (15 ft^3/lb VS destroyed). For RP-5 SHF, the gas production was estimated using the food waste quantity projections presented in Volume III, Chapter 8 and the following assumed gas production ratios:

- 3,200 ft^3 per wet ton of EBS
  - Based on OCSD pilot study and operational data from EBMUD
- 2,230 ft^3 per wet ton of industrial food waste
  - Based on operational data from RP-5 SHF
- Gas production from digestion of FOG was calculated using a VSR of 95%
  - Based on Hyperion FOG study

The gas production estimates from each source are presented in Table 9-1 below.

Table 9-1: Digester Gas Estimates

Digester Gas Source	Year					
	2025	2030	2035	2040	2045	2060
Digester Gas from RP-5 Biosolids Only (annual average)	360	420	460	500	530	570
Digester Gas from RP-5 SHF (annual average)	590	600	620	640	660	700
Digester Gas from RP-1 Biosolids Only (annual average)	600	650	760	730	740	800

9.4 DIGESTER GAS CONDITIONING

Digester gas conditioning will vary depending on the gas utilization alternative selected. For the cogeneration alternatives (described below in Section 9.5), gas conditioning will include the following:

1) Hydrogen sulfide (H_2S) removal with iron sponges or other media such as SulfaTreat™: will remove the H_2S from the digester gas to prevent corrosion in the gas utilization equipment.
2) Refrigeration: accomplishes two goals - partial removal of siloxanes through condensation and removal of moisture.
3) Adsorption: uses activated carbon or silica gel to accomplish the remainder of the siloxane removal.

For the renewable fuel alternatives (described below in Section 9.5), gas conditioning will include the processes above followed by carbon dioxide (CO_2) removal. This process will "upgrade" the digester gas to a quality similar to natural gas, making it usable for CNG or RNG applications upon further compression.

9.5 DEVELOPMENT OF ALTERNATIVES

Five alternatives have been developed for the beneficial use of digester gas. These can be divided into two general categories: cogeneration and production of renewable fuel.

Cogeneration Alternatives

There are three cogeneration alternatives that involve production of power and heat at RP-5. These alternatives include:

1) Modification of the existing REEP facility to meet SCAQMD emission regulations
2) Add a new microturbine system in addition to the existing REEP
3) Add a gas turbine system for combined gas from RP-1 and RP-5 in addition to the existing REEP

Renewable Fuel Alternatives

There are two alternatives that involve the production of renewable fuel with biogas from RP-5 biosolids. These include the following:

1) Production of RNG for injection into SoCal Gas pipeline
2) Production of CNG for vehicle fuel

All five alternatives are outlined below in Figure 9-3.

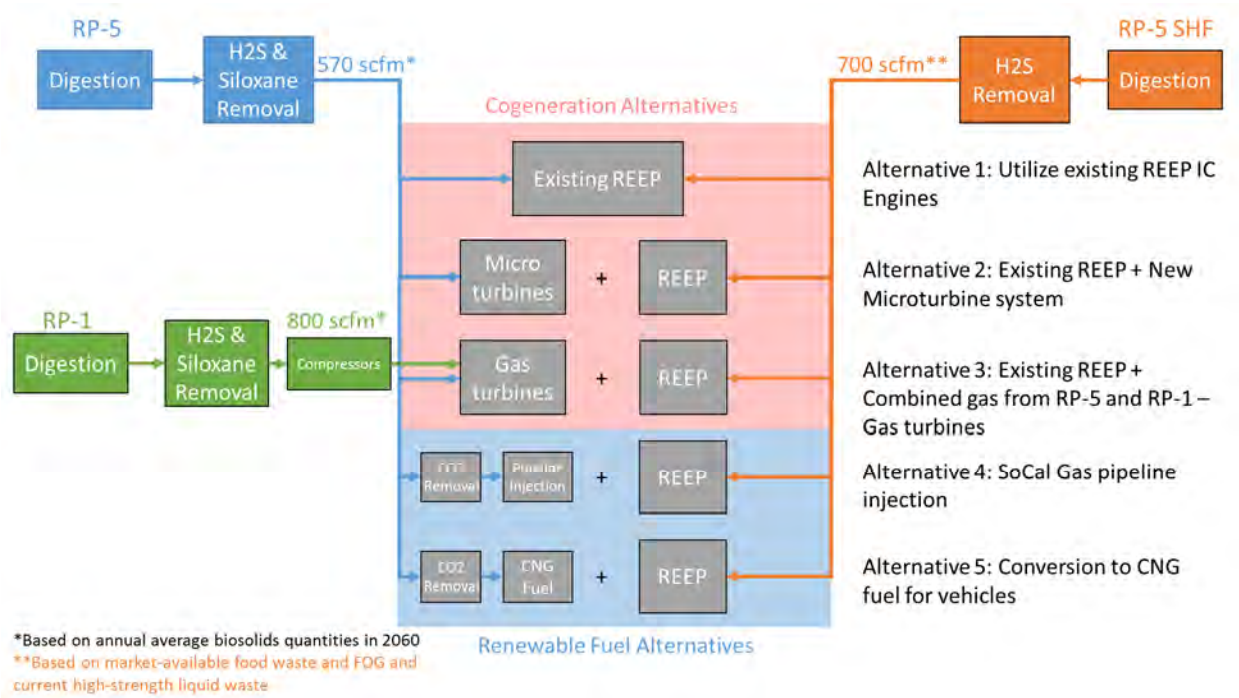


Figure 9-3: Digester Gas Utilization Alternatives

9.5.1 Alternative 1: Use Existing REEP Capacity

This alternative considers using the existing capacity of the two 1.5-MW internal combustion engines to consume digester gas from RP-5 biosolids and RP-5 SHF food waste. Any excess gas beyond the capacity of the two REEP engines will be used at the boiler facility to heat the digesters.

9.5.1.1 *Description of Alternative*

As described in Section 9.1.3, there are two 1.5-MW internal combustion engines currently installed inside the REEP building at RP-5. In order to comply with stricter NOx emissions per SCAQMD Rule 1110.2, this alternative considers the installation of two SCR units, one for each of the two internal combustion engines, including required gas conditioning upstream.

This alternative also includes modifications to the existing REEP heat recovery system to make it operational. This includes using the existing heat recovery silencer, adding heat exchangers, and pumps. A preliminary schematic of the proposed modifications is shown in Figure 9-4 below.

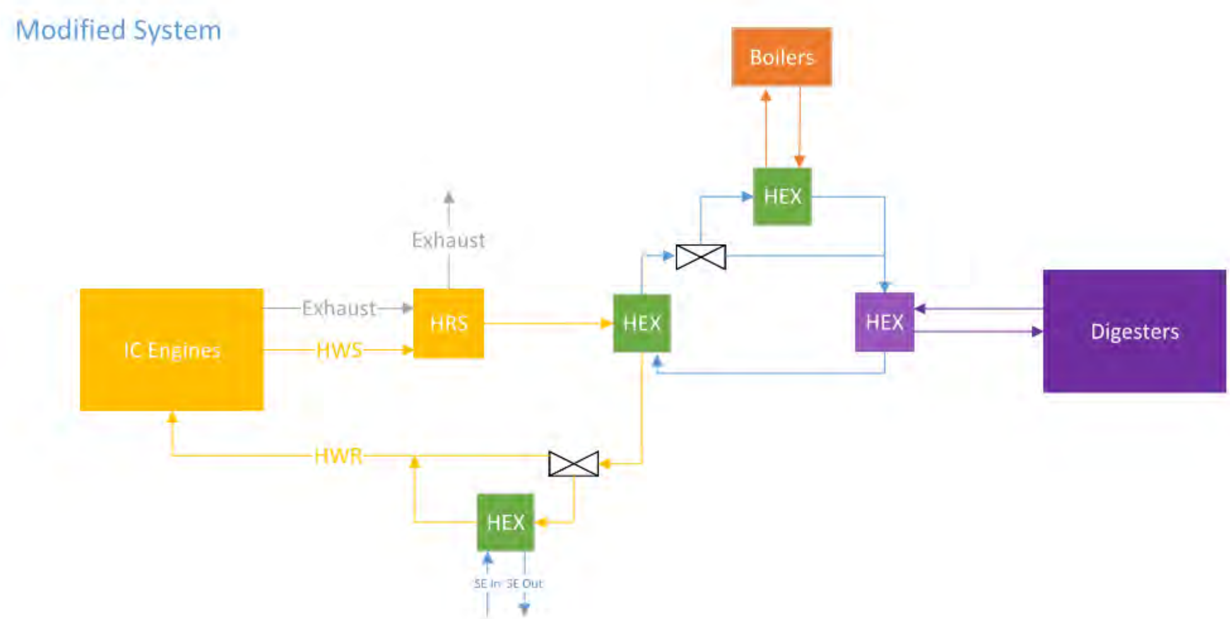


Figure 9-4: Preliminary Schematic of the Modified Heat Recovery System at RP-5 REEP

In addition, the food waste projections indicate that the gas quantity at SHF will increase in the coming years. Therefore, additional equipment is required to handle the increased digester gas produced at SHF. It is estimated that two additional iron sponge vessels of similar capacity to existing will be required for H_2S removal. Based on the information available, the compressors, gas storage, and the flare at SHF are adequate for the increased gas quantities. A process flow schematic for Alternative 1 is shown below in Figure 9-4.

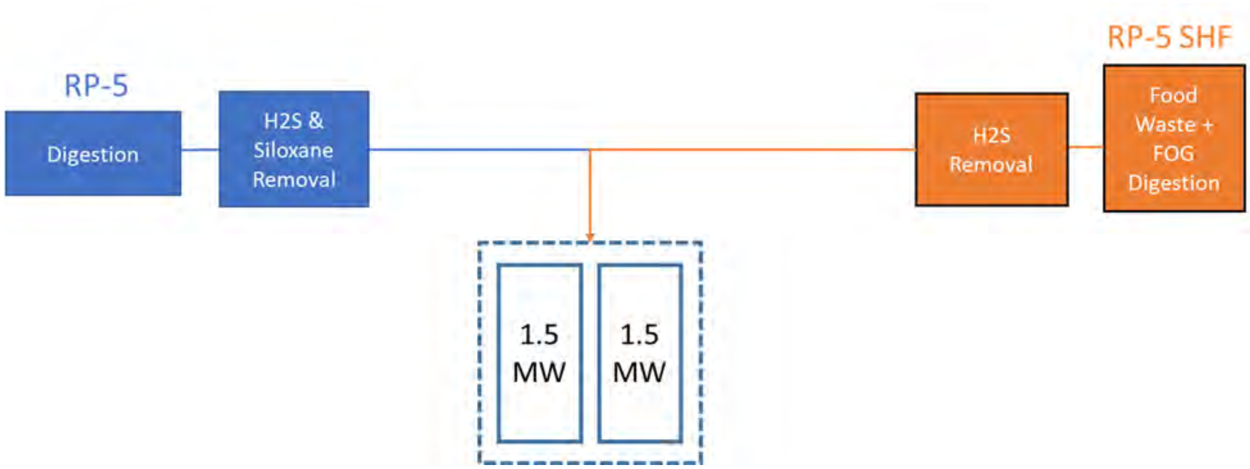


Figure 9-5: Alternative 1 Process Flow Schematic

9.5.1.2 *Design Criteria*

Power and heat production and estimates were calculated based on the following data from REEP operations:

- Internal combustion engine electrical efficiency = 37%
- Internal combustion engine thermal efficiency = 38%
- Digester gas has energy content of 580 British thermal units (BTUs)/ ft^3.

The heat generation and power production potential estimates based on the gas availability are shown below in Table 9-2.

Table 9-2: Alternative 1 Power and Heat Production Potential Estimates

		2025	2030	2035	2040	2045	2060
Power (kW)	RP-5 Biosolids Only	1,342	1,576	1,720	1,875	1,992	2,138
	RP-5 SHF food waste + FOG	2,217	2,281	2,342	2,407	2,474	2,642
Heat (MMBTU/hr)	RP-5 Biosolids Only	4.7	5.5	6.0	6.6	7.0	7.5
	RP-5 SHF food waste + FOG	7.8	8.0	8.2	8.4	8.7	9.3
Totals	**Power: RP-5 + SHF (kW)**	**3,559**	**3,857**	**4,062**	**4,282**	**4,466**	**4,780**
	Heat: RP-5 + SHF (MMBTU/hr)	**12.5**	**13.5**	**14.2**	**15.0**	**15.7**	**16.8**

The power production and heat generation estimates are based on projections of food waste, FOG, and biosolids. Due to the inherent uncertainty of these projections, it is prudent to delay the installation of a third internal combustion engine until the actual availability of the digester feedstocks is determined. In case of excess digester gas availability, gas could be used in a new boiler facility at RP-5 to heat the digesters to thermophilic temperatures. Average heat demand for the digesters is estimated to range from 2.8 million BTU (MMBTU)/hour (hr) in 2023 to 4.9 MMBTU/hr in 2060, which is less than the projected heat recovery from the internal combustion engines. Thus, in the business case evaluation (BCE) calculations credit has only been taken for offsetting natural gas purchases up to the annual average digester heating requirement. Furthermore, in BCE calculations, credit for power production has only been taken up to the installed capacity of REEP – 3 MW.

Parsons recommends using the capacity of the existing REEP engines until the food waste program is mature and the quantities of food waste and FOG received at RP-5 SHF require the installation of a third internal combustion engine. Alternatively, digester gas beyond the capacity of the existing REEP engines could be used to explore renewable fuel alternatives, which will be described in more detail in Sections 9.5.4 and 9.5.5.

9.5.1.3 *Site Layout*

A proposed site layout for Alternative 1 is shown in Figure 9-6. The proposed location of the gas conditioning system is tentative.

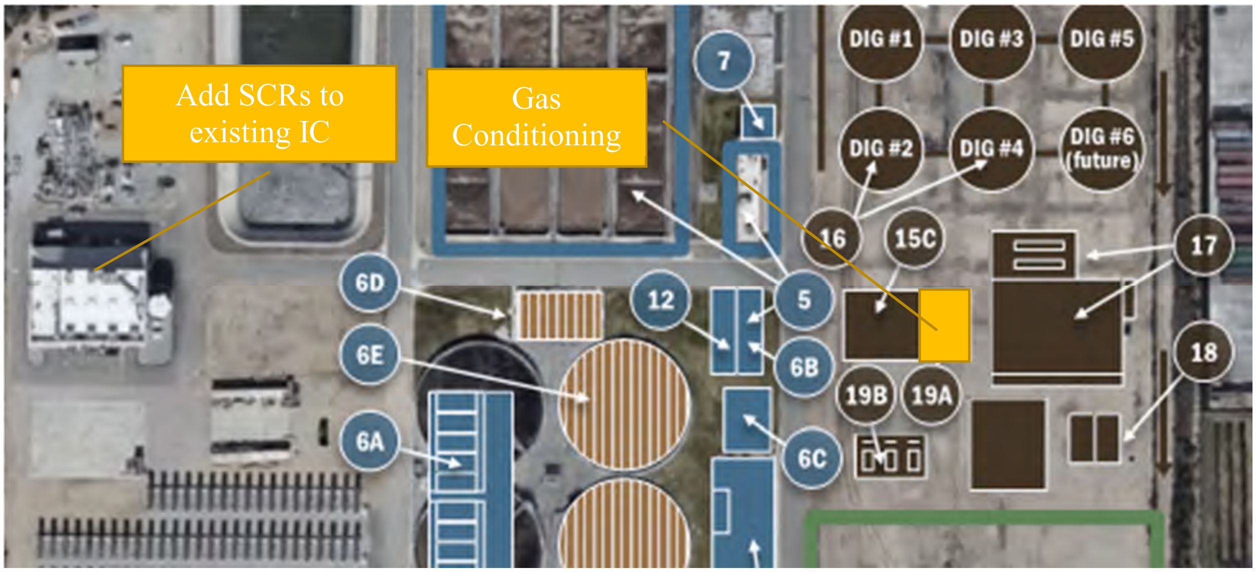


Figure 9-6: Alternative 1 – Proposed Site Layout

9.5.1.4 *Capital and Operations and Maintenance (O&M) costs*

Capital and O&M costs were calculated based on preliminary quotes from vendors and experience from past projects with the following assumptions:

1. Unit cost for operation and maintenance on internal combustion engines is assumed to be 2.5 cents per kilowatt-hour (kWh).
2. Power production offsets electricity costs at 12.5 cents per kWh.
3. Heat production offsets natural gas costs at 50 cents per therm.
4. Uptime for cogeneration technologies is assumed to be 90%.

Table 9-3 shows the capital cost estimate and Table 9-4 shows the O&M cost estimate associated with this alternative.

Table 9-3: Alternative 1 Capital Costs

Item	Cost
Two (2) Selective Catalytic Converters	$1,002,000
Gas Conditioning System at RP-5	$1,845,000
Gas Conditioning System at SHF	$645,000
Existing REEP Heat Recovery System Modifications	$505,000
Alternative 1 Base Cost	**$4,006,000**
Overhead & Profit, Inflation, Bonds & Insurances, Contingency	$2,604,000
Total Construction Cost	**$6,610,000**
Design & Administration (20%)	$1,322,000
Total Project Cost	**$7,932,000**

Table 9-4: Alternative 1 – 2045 O&M Costs and Savings

Item	Savings
O&M – includes labor, power (including parasitic loads), and chemicals	($802,000)
Repair and replacement of equipment parts	($70,000)
Savings – beneficial use of digester gas (power and heat)	$3,156,000
Net Annual Savings	**$2,284,000**

9.5.2 Alternative 2: New Cogeneration System at RP-5 (Microturbines)

This alternative considers a new cogeneration system using microturbines at RP-5. Microturbines were considered as the cogeneration technology of choice for this alternative because they are modular in nature and could potentially meet SCAQMD emission regulations without any exhaust treatment.

9.5.2.1 *Description of Alternative*

For this alternative, a new cogeneration system (microturbines) is proposed for the gas from RP-5 biosolids only. The gas from RP-5 SHF will continue to be sent to the existing two internal combustion engines at the REEP facility. A process flow schematic for Alternative 2 is shown below in Figure 9-7.

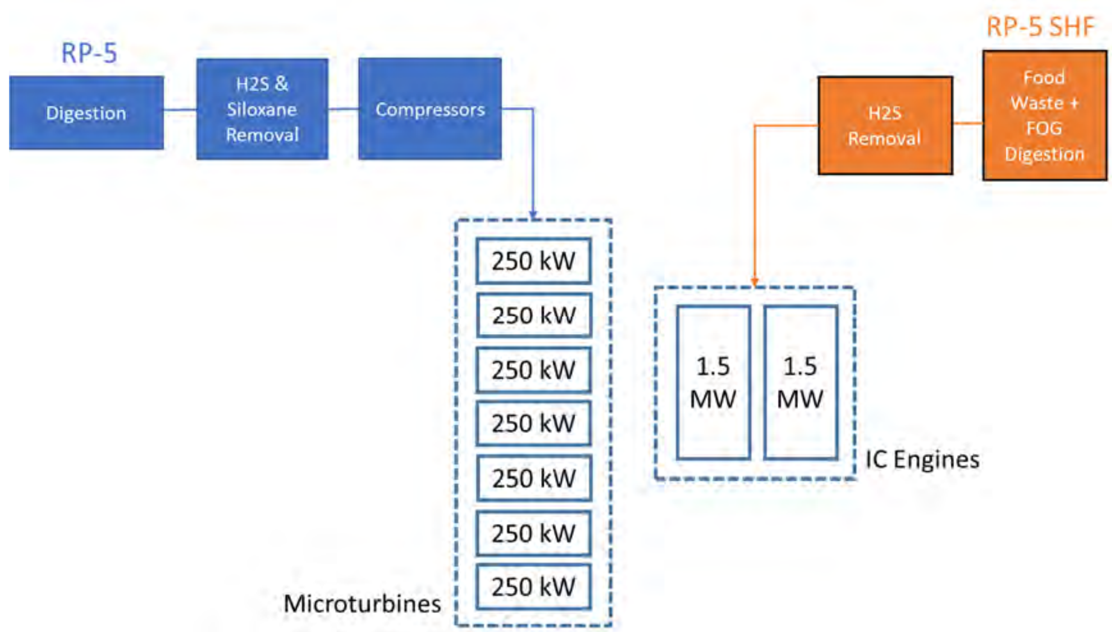


Figure 9-7: Alternative 2 Process Flow Schematic

9.5.2.2 *Design Criteria*

Power and heat production estimates were calculated based on the following assumptions:

- Microturbine electrical efficiency = 30%.

- Microturbine thermal efficiency = 35%.
- Internal combustion engine electrical efficiency = 37%.
- Internal combustion engine thermal efficiency = 38%.
- Digester gas has energy content of 580 BTU/ft^3.

The power and heat production potential estimates based on the gas availability are shown below in Table 9-5 for Alternative 2 which considers the installation of seven 250 kW microturbines.

Table 9-5: Alternative 2 Power and Heat Production Potential Estimates

		2025	2030	2035	2040	2045	2060
Power (kW)	RP-5 Biosolids Only (microturbines)	1,088	1,278	1,394	1,520	1,615	1,734
	SHF food waste + FOG (internal combustion engines)	2,217	2,281	2,342	2,407	2,474	2,642
Heat (MMBTU/hr)	RP-5 Biosolids Only (microturbines)	4.3	5.1	5.6	6.1	6.4	6.9
	SHF food waste + FOG (internal combustion engines)	7.8	8.0	8.2	8.4	8.7	9.3
Totals	**Power: RP-5 + SHF (kW)**	**3,305**	**3,559**	**3,737**	**3,927**	**4,089**	**4,375**
	Heat: RP-5 + SHF (MMBTU/hr)	**12.1**	**13.1**	**13.8**	**14.5**	**15.1**	**16.2**

9.5.2.3 *Site Layout*

The proposed location for the microturbines is shown in Figure 9-8 below. The microturbines can be located outdoors on a concrete pad, possibly with a canopy, but do not have to be located within a building.

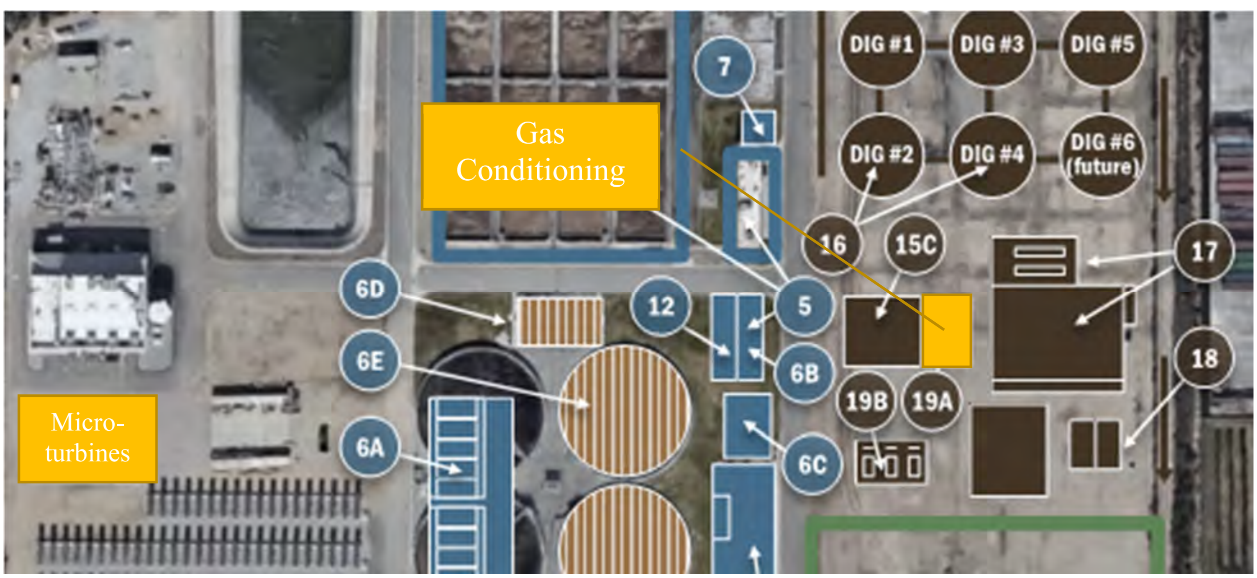


Figure 9-8: Alternative 2 – Proposed Site Layout

9.5.2.4 *Capital and O&M costs*

Capital and O&M costs were calculated based on preliminary quotes from vendors and experience from past projects with the following assumptions.

1. O&M cost for microturbines is assumed to be 3 cents per kWh.
2. Uptime for both cogeneration technologies is assumed to be 90%.
3. Power production offsets electricity costs at 12.5 cents per kWh.
4. Heat production offsets natural gas costs at 50 cents per therm.

Table 9-6 shows the capital cost estimate and Table 9-7 shows the O&M cost estimate associated with this alternative.

Table 9-6: Alternative 2 Capital Costs

Item	Cost
Seven (7) 250 kW microturbines and associated equipment	$10,329,000
Gas Conditioning System at RP-5	$1,845,000
Microturbines Compression Station	$738,000
Two (2) Selective Catalytic Converters	$1,002,000
Existing REEP Heat Recovery System Modifications	$505,000
Gas Conditioning at SHF	$654,000
Alternative 2 Base Cost	**$15,073,000**
Overhead & Profit, Inflation, Bonds & Insurances, Contingency	$9,797,000
Total Construction Cost	**$24,870,000**
Design & Administration (20%)	$4,974,000
Total Project Cost	**$29,844,000**

Table 9-7: Alternative 2 – 2045 O&M Costs and Savings

Item	Savings
O&M – includes labor, power (including parasitic loads), and chemicals	($1,156,000)
Repair and replacement of equipment parts	($140,000)
Savings – beneficial use of digester gas (power and heat)	$4,229,000
Net Annual Savings	$2,933,000

9.5.3 Alternative 3: Centralized Cogeneration – Transfer DG from RP-1 to RP-5

In this alternative, a centralized cogeneration facility is proposed to use gas from both RP-1 and RP-5. At the proposed scale, gas turbines are offer the most efficient combined heat and power system.

9.5.3.1 *Description of Alternative*

This alternative includes the installation of an interconnecting biogas pipeline between RP-1 and RP-5, as shown in Figure 9-9 below. It is assumed that the easement for the existing primary effluent sewer line between RP-1 and RP-5 will be used to install the proposed digester gas pipeline.

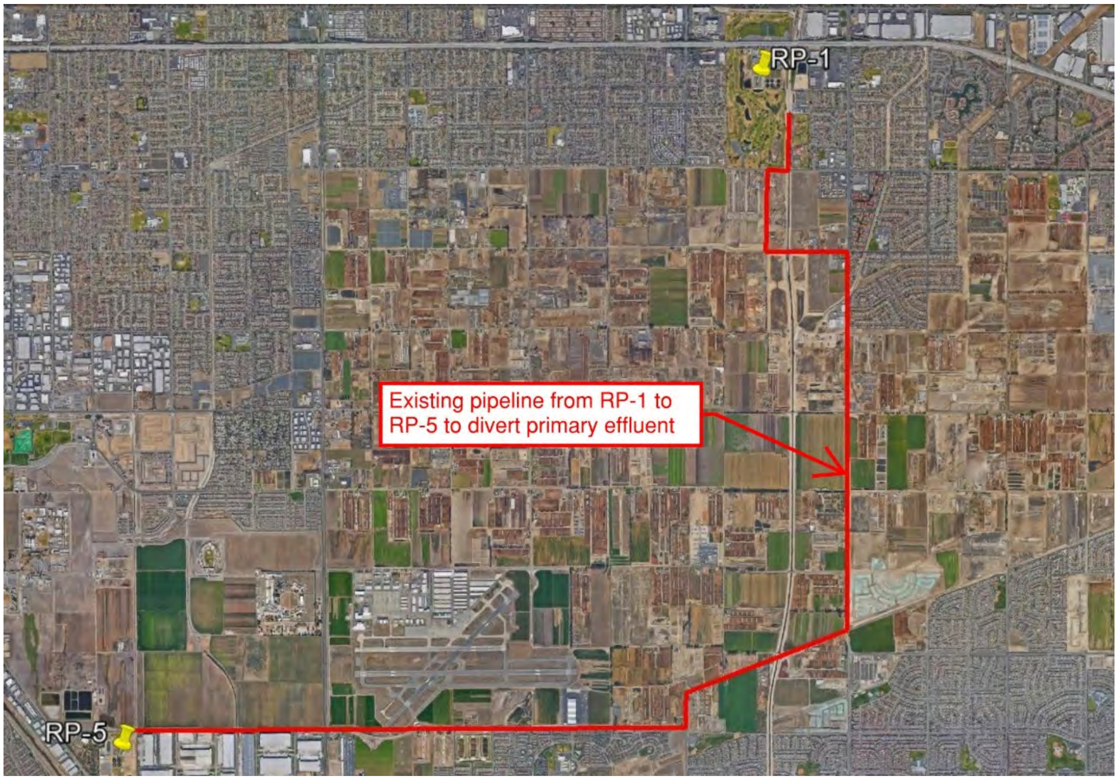


Figure 9-9: RP-1 to RP-5 Gas Pipeline – Potential Alignment

Potential constraints for this pipeline include permitting from the California Environmental Quality Act (CEQA), local businesses, public and private easements and increased O&M activities involving booster stations, purge stations, condensate traps, and leak detection. Figure 9-10 shows the proposed process flow schematic for this Alternative. RP-1 gas must be treated onsite before being sent to RP-5 to minimize corrosion and condensate accumulation in the cross-country pipeline.

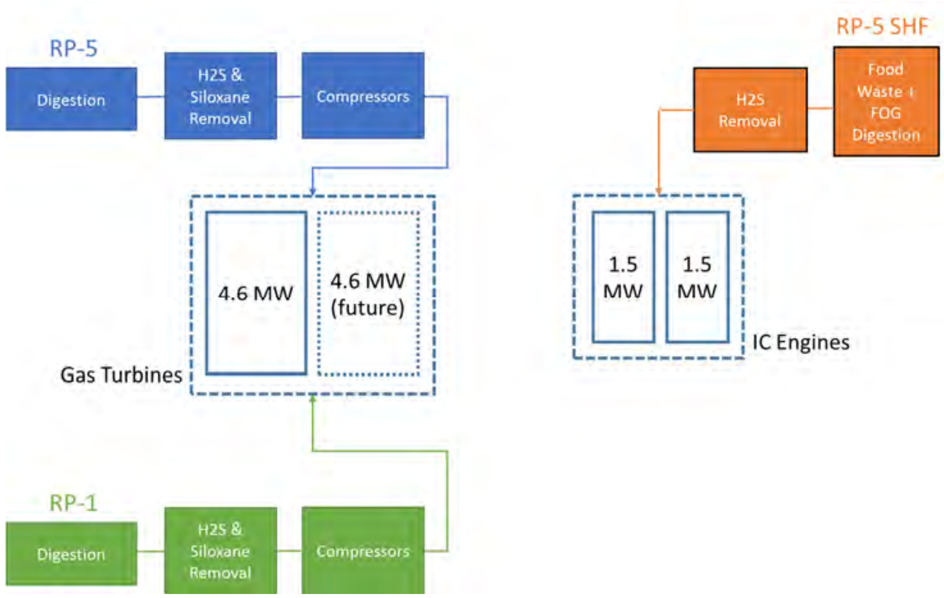


Figure 9-10: Alternative 3 Process Flow Schematic

9.5.3.2 *Design Criteria*

Power and heat production estimates were calculated based on the following assumptions:

- Gas turbines electrical efficiency = 38%.
- Gas turbines thermal efficiency = 35%.
- Internal combustion engines electrical efficiency = 37%.
- Internal combustion engines thermal efficiency = 38%.
- Digester gas has energy content of 580 BTU/ft^3.

The power production potential projections based on the gas availability are shown below in Table 9-8.

Table 9-8: Alternative 3 Power and Heat Production Potential Estimates

		2025	2030	2035	2040	2045	2060
Power (kW)	RP-1 + RP-5 Biosolids (gas turbines)	3,714	4,119	4,703	4,743	4,929	5,275
	RP-5 SHF food waste + FOG (internal combustion engines)	2,217	2,281	2,342	2,407	2,474	2,642
Heat (MMBTU/hr)	RP-1 + RP-5 Biosolids (gas turbines)	11.7	13.0	14.8	14.9	15.5	16.6
	RP-5 SHF food waste + FOG (internal combustion engines)	7.8	8.0	8.2	8.4	8.7	9.3
Totals	**Power: RP-1 + RP-5 + SHF (kW)**	**5,930**	**6,400**	**7,045**	**7,150**	**7,403**	**7,917**
	Heat: RP-1 + RP-5 + SHF (MMBTU/hr)	**19.4**	**20.9**	**23.0**	**23.4**	**24.2**	**25.9**

The projected power production potential in 2045 is approximately 4.9 MW. The only commercially available gas turbine on the market that can meet the SCAQMD emissions is a Solar Mercury Turbine at 4.6 MW capacity. Thus, only one 4.6 MW gas turbines is recommended in this alternative, with room for one additional turbine in the future. Any excess gas beyond the capacity of one gas turbine can be used in boilers.

9.5.3.3 *Site Layout*

The proposed site layout for Alternative 3 is shown in Figure 9-11 below.

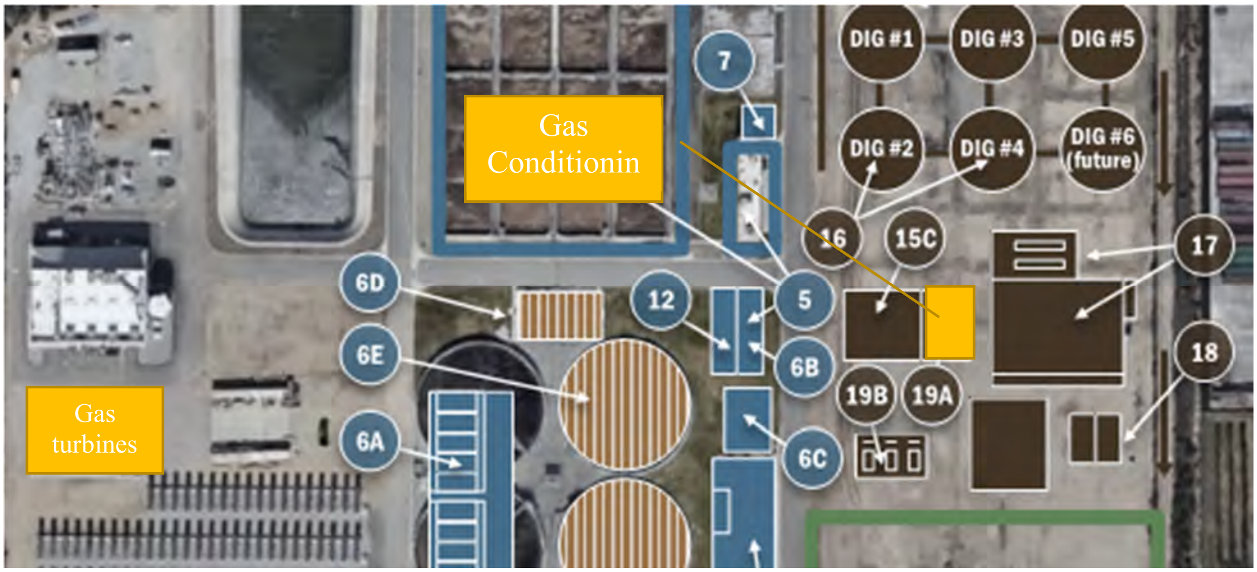


Figure 9-11: Alternative 3 – Proposed Site Layout

9.5.3.4 *Capital and O&M costs*

Capital and O&M costs were calculated based on preliminary quotes from vendors and experience from past projects with the following assumptions:

1. O&M cost for 4.6 MW gas turbine is $25,000 per month.
2. Uptime for both cogeneration technologies is assumed to be 90%.
3. Power production offsets electricity costs at 12.5 cents per kWh.
4. Heat production offsets natural gas costs at 50 cents per therm.

Estimated capital costs for Alternative 3 are shown in Table 9-9 and estimated O&M costs and savings for the year 2045 are shown in Table 9-10.

Table 9-9: Alternative 3 Capital Costs

Item	Cost
One (1) 4.6 MW Gas Turbines and associated equipment	$12,912,000
RP-5 Gas Conditioning System	$1,845,000
RP-1 Gas Conditioning System	$2,767,000
Gas Turbines Compression Station	$1,845,000
RP-1 to RP-5 Gas Pipeline (8 miles, 12-inch diameter)	$12,100,000
RP-1 Compression Station	$461,000
Two (2) Selective Catalytic Converters	$1,002,000
Existing REEP Heat Recovery System Modifications	$505,000
Gas Conditioning at SHF	$654,000
Alternative 3 Base Cost	**$34,091,000**
Overhead & Profit, Inflation, Bonds & Insurances, Contingency	$22,159,000
Total Construction Cost	**$56,250,000**
Design & Administration (20%)	$11,250,000
Total Project Cost	**$67,500,000**

Table 9-10: Alternative 3 – 2045 O&M Costs and Savings

Item	Savings
O&M – includes labor, power (including parasitic loads), and chemicals	($2,253,000)
Repair and replacement of equipment parts	($215,000)
Savings – beneficial use of digester gas (power and heat)	$7,171,000
Net Annual Savings	**$4,703,000**

9.5.4 Alternative 4: Convert DG to Pipeline-Quality Natural Gas

In Alternative 4, digester gas will be converted to high-quality natural gas that can be directly injected into the available SoCal gas pipeline in the vicinity of the treatment plant.

9.5.4.1 *Description of Alternative*

Alternative 4 considers the conversion of digester gas generated at RP-5 to RNG. In addition to moisture, H_2S, and siloxane removal required for cogeneration, the biogas will undergo CO_2 stripping before compression and injection to a SoCal Gas pipeline. The CO_2 stripping process will reduce the quantity of gas available for injection by approximately 40%. This alternative considers the continuation of the current REEP operation with gas from RP-5 SHF. Figure 9-12 shows the proposed schematic for this alternative.

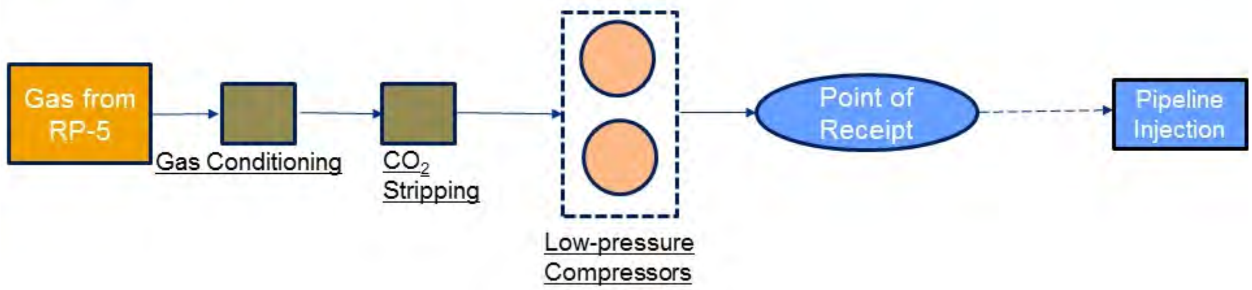


Figure 9-12: Alternative 4 Process Flow Schematic

9.5.4.2 *Applicable Incentives*

One of the primary market drivers to produce RNG is the applicable incentives. There are two incentive programs applicable to this project: Renewable Fuel Standards (RFS) by the US Environmental Protection Agency (EPA) and Low Carbon Fuel Standard (LCFS) by the California Air Resources Board (CARB).

Renewable Fuel Standards (RFS) Program: This program, administered by the EPA, encourages the production of renewable fuel such as CNG as transportation fuel or indirect renewable fuel consumption due to pipeline injection. RFS credits are calculated based on the Renewable Identification Numbers (RINs) generated. In other words, RINs are the currency for the RFS program.

Low Carbon Fuel Standard (LCFS) Program: The LCFS program is part of a statewide California rule enacted in 2007. The program involves a market-based cap and trade system in which producers of low-carbon renewable fuels can sell or trade credits based on the quantity of the fuel produced.

While these incentives have the potential to make the economics of renewable fuel alternatives favorable, the current incentive market is volatile. It was noted that these incentives have dropped significantly in the recent past, and this volatility will affect the economics of these alternatives accordingly.

Both RFS and LCFS incentives are intended to promote renewable fuels in the transportation industry. Therefore, for pipeline injection, it is estimated that the available incentives will be approximately half of the incentives for production of CNG for vehicle fuel.

9.5.4.3 *Design Criteria*

Alternative 4 gas quantity projections are shown below in Table 9-11. Methane content in digester gas is approximately 60% and methane recovery in the CO_2 removal process is about 90%.

Table 9-11: Alternative 4 Gas Quantity Projections

RP-5 Digester Gas	Year					
	2025	2030	2035	2040	2045	2060
Digester Gas before CO_2 Removal (scfm)	360	420	460	500	530	570
RNG (scfm)	190	230	250	270	290	310
RNG (therms/year)	1,010,000	1,186,000	1,294,000	1,411,000	1,499,000	1,609,000

9.5.4.4 *Site Layout*

The proposed site layout for Alternative 4 is shown in Figure 9-13 below.

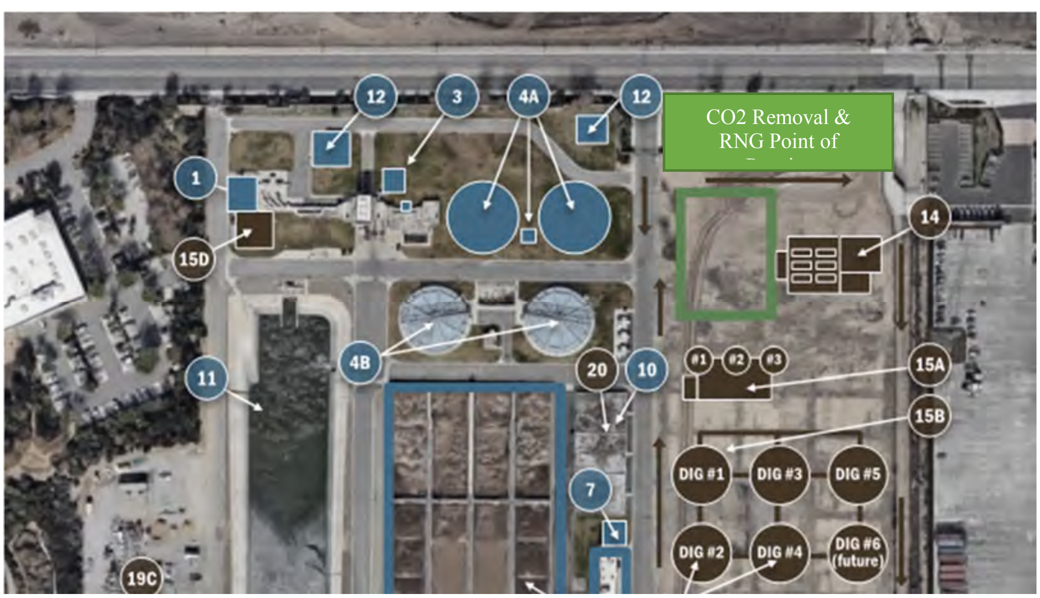


Figure 9-13: Alternative 4 - Proposed Site Layout

9.5.4.5 *Capital and O&M costs*

In addition to gas treatment, this alternative considers the cost of a 1-mile pipeline extension to the nearest SoCal Gas pipeline with adequate capacity. The estimated interconnection fee charged by SoCal Gas is also included. The following assumptions are made in estimating the costs:

1. RNG sale = $0.50 per therm.
2. RIN Incentive = $0.665 per gallon of gas equivalent (GGE)
3. LCFS Incentive = $4.415 per MMBTU.
4. Uptime for cogeneration technologies is assumed to be 90%.
5. Power production offsets electricity costs at 12.5 cents per kWh.
6. Heat production offsets natural gas costs at 50 cents per therm.

Capital costs for Alternative 4 are shown in Table 9-12 and O&M costs and savings in 2045 are shown in Table 9-13.

Table 9-12: Alternative 4 Capital Costs

Item	Cost
RP-5 Gas Conditioning System (H_2S and Siloxane Removal)	$1,845,000
CO_2 Removal System	$2,213,000
Low Pressure Compression Station	$922,000
Pipeline Extension (1 mile)	$968,000
Point of Receipt Fee	$2,420,000
Two (2) Selective Catalytic Converters for existing internal combustion engines	$1,002,000
Existing REEP Heat Recovery System Modifications	$505,000
Gas Conditioning at SHF	$654,000
Alternative 4 Base Cost	**$10,529,000**
Overhead & Profit, Inflation, Bonds & Insurances, Contingency	$6,844,000
Total Construction Cost	$17,373,000
Design & Administration (20%)	$3,474,600
Total Project Cost	**$20,847,600**

Table 9-13: Alternative 4 – 2045 O&M Costs and Savings

Item	Savings
O&M – includes labor, power (including parasitic loads), and chemicals	($861,000)
Repair and replacement of equipment parts	($34,000)
Power and Heat Production – Existing REEP Engines	$2,438,000
RNG sale	$675,000
RIN Incentives	$787,000
LCFS Incentives	$596,000
Net Annual Savings	**$3,601,000**

9.5.5 Alternative 5: Convert DG to Compressed Natural Gas (CNG) for Vehicular Fuel

In this alternative, digester gas will be used to produce CNG for vehicular fuel.

9.5.5.1 *Description of Alternative*

In addition to CO_2 removal, a high pressure storage and filling station for vehicles will be required under this alternative. Economic viability of this alternative depends on the applicable incentives as well as utilizing all the produced CNG as vehicular fuel, which requires a large fleet of CNG vehicles (see Table 9-14 below). Figure 9-14 shows the proposed schematic for Alternative 5.

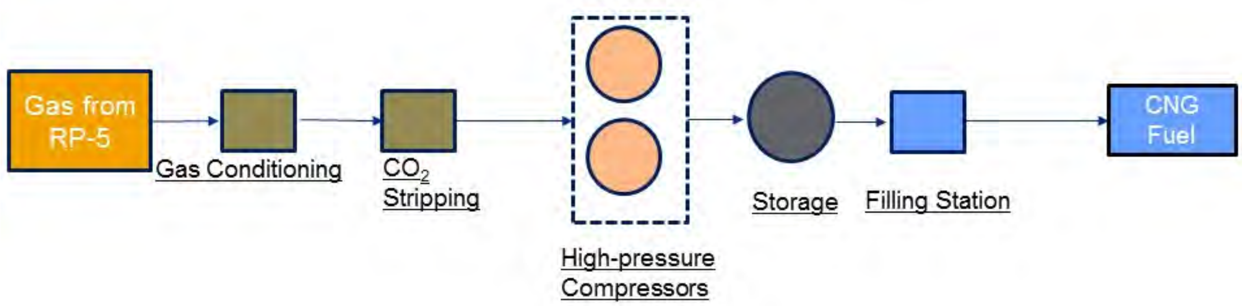


Figure 9-14: Alternative 5 Process Flow Schematic

9.5.5.2 *Applicable Incentives*

The same incentive programs for RNG fuel discussed in the previous section (RFS and LCFS) apply to production of CNG fuel. However, CNG production receives the full credits under both programs, while RNG receives only half of the credit.

9.5.5.2.1 *Design Criteria*

As in Alternative 4, methane content of digester gas is 60% and methane recovery is about 90%. The gas quantities for Alternative 5 are shown in Table 9-14 below.

Table 9-14: Alternative 5 Gas Quantity Projections

RP-5 Digester Gas	Year					
	2025	2030	2035	2040	2045	2060
Digester Gas before CO2 Removal (scfm)	360	420	460	500	530	570
CNG (scfm)	190	230	250	270	290	310
CNG (GGE/year)	886,000	1,041,000	1,135,000	1,238,000	1,315,000	1,411,000

9.5.5.2.2 Site Layout

The proposed site layout for Alternative 5 is shown in Figure 9-15 below.

Figure 9-15: Alternative 5 – Proposed Site Layout

9.5.5.2.3 Capital and O&M costs

For this alternative a high-pressure compression station as well as CNG storage and filling station were considered in addition to the gas treatment and CO_2 removal systems. The assumptions used to estimate costs are as follows:

1. Sale of CNG = $1.50 per GGE
2. RIN Incentives = $1.33 per GGE
3. LCFS Incentives = $8.83 per MMBTU
4. Uptime for cogeneration technologies is assumed to be 90%.
5. Power production offsets electricity costs at 12.5 cents per kWh.
6. Heat production offsets natural gas costs at 50 cents per therm.

The estimated capital costs for Alternative 5 are shown in Table 9-15 and the 2045 O&M costs and savings are shown in Table 9-16.

Table 9-15: Alternative 5 Capital Costs

Item	Cost
RP-5 Gas Conditioning System (H_2S and Siloxane Removal)	$1,845,000
CO_2 Removal System	$2,213,000
High Pressure Compression Station	$1,845,000
CNG Filling Station/Storage	$1,845,000
Two (2) Selective Catalytic Converters	$1,002,000
Existing REEP Heat Recovery System Modifications	$505,000
Gas Conditioning at SHF	$654,000
Alternative 5 Base Cost	**$9,909,000**
Overhead & Profit, Inflation, Bonds & Insurances, Contingency	$6,441,000
Total Construction Cost	$16,350,000
Design & Administration (20%)	$3,270,000
Total Project Cost	**$19,620,000**

Table 9-16: Alternative 5 – 2045 O&M Costs and Savings

Item	Savings
O&M – includes labor, power, and chemicals	($961,000)
Repair and replacement of equipment parts	($64,000)
Power Production – Existing REEP Engines	$2,438,000
Savings – RNG sale	$1,775,000
RIN Incentives	$1,574,000
LCFS Incentives	$1,191,000
Net Annual Savings	**$5,954,000**

9.6 DIGESTER GAS STORAGE EVALUATION

Digester gas production varies depending on changes in organic loading parameters and operating conditions. Gas storage is important because it provides equalization of gas flows, hence facilitating smooth operation of gas conditioning equipment as well as maximizing the cogeneration potential of digester gas. For the digester gas produced in excess of the amount that can be stored or utilized beneficially, waste gas flares are provided to burn the excess gas. For details regarding digester gas storage, refer to Chapter 7.5 on Digester Gas Storage and Flares.

9.7 BUSINESS CASE EVALUATION (BCE)

9.7.1 Introduction

A BCE was performed to determine the alternative with the lowest life-cycle cost. The following assumptions were used in the analysis.

- Internal combustion engine electrical efficiency = 37%.

- Internal combustion engine thermal efficiency = 38%.
- Microturbines electrical efficiency = 30%.
- Microturbines thermal efficiency = 35%.
- Gas turbines electrical efficiency = 38%.
- Gas turbines thermal efficiency = 35%.
- Cogeneration system uptime = 90%.
- Power produced offsets electricity costs at $0.125/kWh.
- Heat recovered offsets natural gas costs at $0.50/therm.
- Benefits from heat recovery were only considered up to the annual average heat demand of the digesters.
- Power production from internal combustion engines was limited to the existing capacity (3 MW) for the BCE.
- Gas from RP-5 SHF is sent to the existing RP-5 REEP engines in all alternatives, however, not all gas generated can be used in the engines in Alternative 1.

9.7.2 BCE Results

BCE results are summarized below in Table 9-17.

Table 9-17: BCE Results Summary

Inland Empire Utilities Agency

Inland Empire UTILITIES AGENCY Alternatives Net Present Value Analysis

		Results ($000s)		
Agency:	Inland Empire Utilities Agency			
Project/Problem:		Capital Cost	30-year NPV	Benefit over 'Do Nothing'
Alternative 1	**DG Alt 1 - Existing IC Engines**	$7,932,000	$17,994,618	
Alternative 2	**DG Alt 2 - Microturbines**	$29,844,000	$40,984,453	$22,989,836
Alternative 3	**DG Alt 3 - Centralized Cogen w/ Gas Turbines**	$67,500,000	$49,994,494	$31,999,876
Alternative 4	**DG Alt 4 - RNG for Pipeline Injection**	$20,847,600	$2,418,047	($15,576,571)
Alternative 5	**DG Alt 5 - CNG for Vehicle Fuel**	$19,620,000	$57,917,283	$39,922,665

Year of analysis:	2016
Escalation rate:	3.00%
Discount rate:	2.00%

9.8 CONCLUSIONS AND RECOMMENDATIONS

9.8.1 Conclusions

This analysis is subject to some level of uncertainty, especially regarding the food waste quantities. The collection program is not yet mature, so the projected food waste quantities may not be fully realized for several years. Due to uncertainty in the quantity of food waste that will actually be collected and digested at RP-5 SHF, it is prudent to utilize the capacity of the existing REEP facility to its fullest before installing additional energy recovery facilities. Therefore, Parsons recommends the Agency pursue Alternative 1 in this project while exploring alternative digester gas utilization technologies in the future, such as conversion to RNG/CNG.

9.8.2 Recommended Alternative

Parsons recommends Alternative 1, which includes installing new SCR units on each of the existing internal combustion engines, a new gas conditioning system (H_2S and siloxane removal) to treat RP-5 digester gas, an expanded H_2S removal system for RP-5 SHF gas, and modifications to the RP-5 REEP heat recovery system. The schematic for this alternative is shown below in Figure 9-16. A preliminary layout for the new gas conditioning system at RP-5 is shown in Figure 9-17 below.

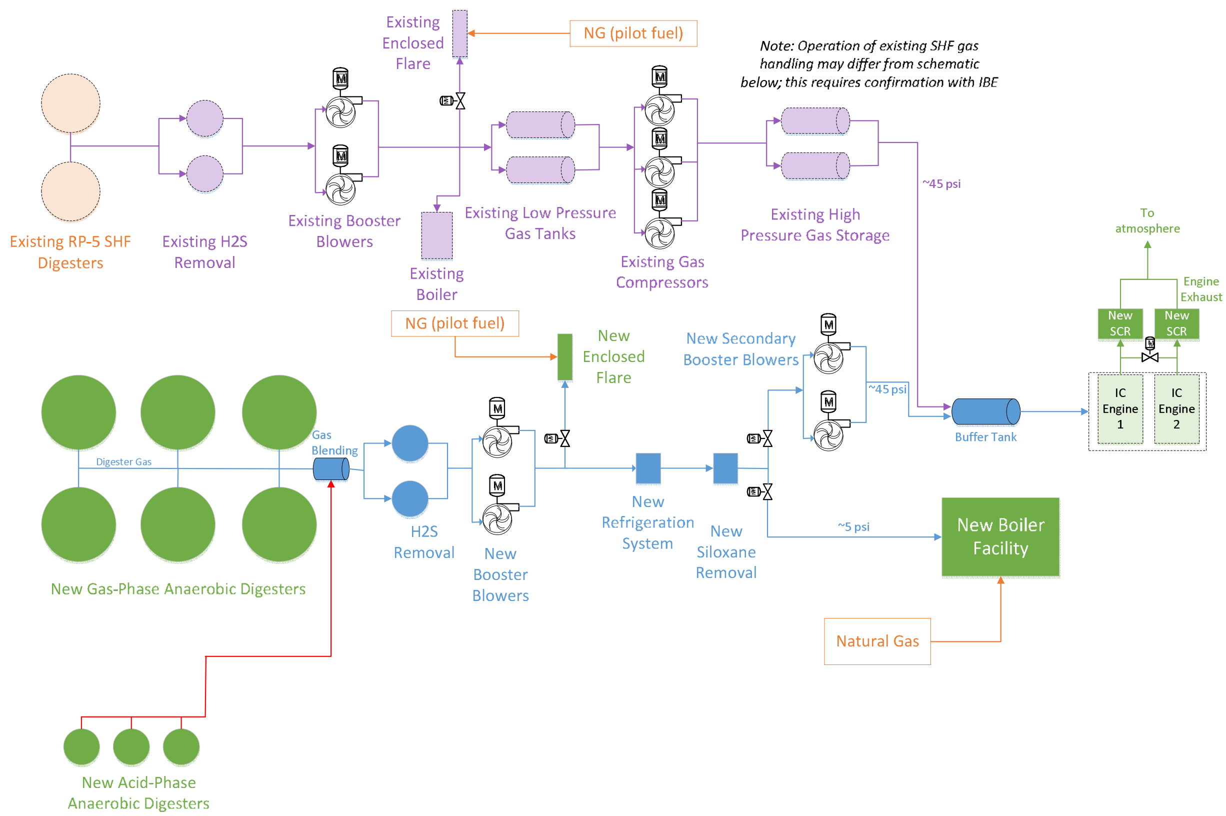


Figure 9-16: Recommended Alternative Gas Utilization Schematic

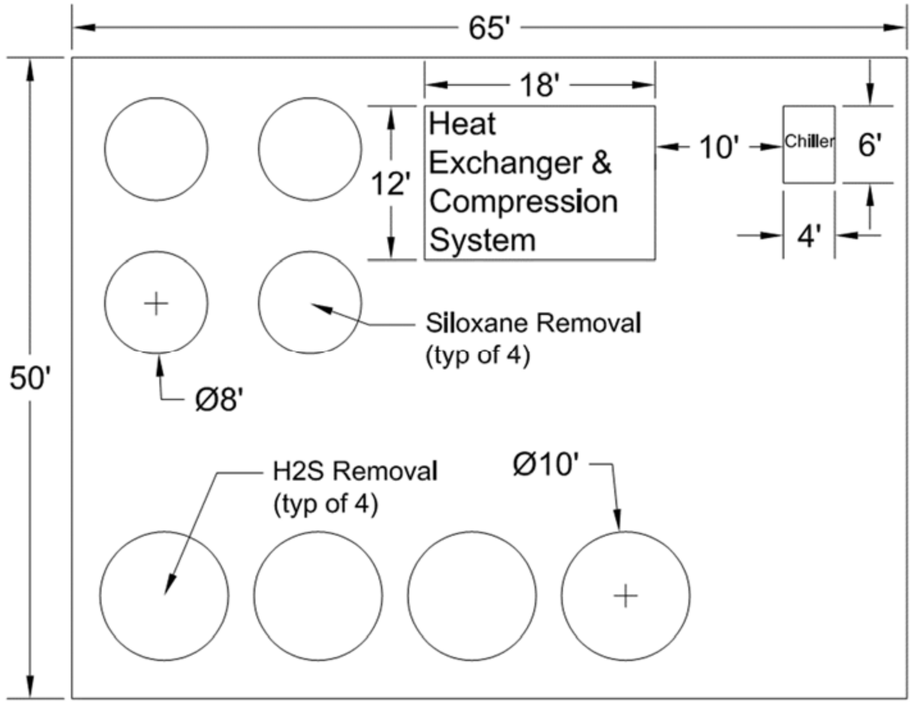


Figure 9-17: Preliminary Gas Conditioning System Layout

THIS PAGE INTENTIONALLY LEFT BLANK.

Inland Empire Utilities Agency
A MUNICIPAL WATER DISTRICT

RP-5 Solids Treatment Facility Business Case Evaluations and Detailed Cost Estimates

Predesign Report
Volume III, Exhibit I

February 28, 2017

submitted by

PARSONS

in association with

Brown AND Caldwell

Mountain Ave. Lift Station - Pre-packaged Cost Estimate						
Item No.	**Description**	**No. of Items**	**Units**	**Quantity**	**Unit Cost ($)**	**Cost ($)**
	EQUIPMENT					
1	Pre-packaged Lift Station			1	$ 112,000	$ 112,000
2	Excavation			1	$ 14,000	$ 14,000
	Equipment Installation		%		15%	$16,800
	Electrical & Instrumentation, SCADA interface		%		15%	$16,800
	FITTINGS, VALVES, FLOW METER					
3	8"x6" Reducer			2	$ 239	$ 500
4	8-inch 90-degree elbow			4	$ 350	$ 1,400
5	8-inch tee			1	$ 521	$ 521
6	Quick disconnect			1	$ 1,200	$ 1,200
	Equipment Installation		%		45%	$1,629
	PIPELINE					
7	8-inch Pipeline	50	ft	1	$ 192	$ 10,000
8	10-inch Pipeline	40	ft	1	$ 200	$ 8,000
9	8-inch Pipeline	3100	ft	1	$ 192	$ 595,000
	MANHOLE MODIFICATIONS					
10	Connect to Kimball manhole, add diversion manhole			1	$ 20,000	$ 20,000
	SITE IMPROVMENTS					
11	Block Wall			1	$ 9,700	$ 9,700
12	AC Pavement			1	$22,000	$ 22,000
13	Slide Gate			2	$ 9,000	$ 18,000
14	Security Gate			1	$3,200	$ 3,200
15	Fence			1	$ 7,425	$ 7,425
	Total Equipment and Structures Cost					**$858,000**
3.1	Sales Tax		%		9%	$28,400
	Unit Cost Estimate					**$886,000**

Inland Empire Utilities Agency
IEBL Discharge Station Relocation
Alternatives Net Present Value Analysis

Agency:	Inland Empire Utilities Agency		Results ($000s)	
Project/Problem:		Capital Cost	30-year NPV	Benefit over 'Do Nothing'
Alternative 1	**Alternative 1 - West of CCWRF Headworks**	$ 340,000	($568,958)	
Alternative 2	**Alternative 2 - Northeast of RP-5**	$ 1,080,000	($1,949,540)	($1,380,582)
Alternative 3	**Alternative 3 - North of SHF**	$ 800,000	($1,084,643)	($515,685)
Alternative 4				$568,958
Alternative 5				$568,958

Year of analysis:	2016
Escalation rate:	3.00%
Discount rate:	2.00%

Make entries in yellow cells only.

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2016	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	2.00%	Running costs	

Inland Empire Utilities Agency

Life Cycle Alternative Cost Analysis ($000s)
Alternative 1A

Year

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Expressed in 2016 dollars, unescalated																														
Capital Outlays																														
Construction - Alternative 1			34,000	34,000	34,000	68,000	68,000	102,000																						
Other																														
Other																														
Other																														
Total capital outlays			**34,000**	**34,000**	**34,000**	**68,000**	**68,000**	**102,000**																						
Benefits:																														
Other																														
Other																														
Other																														
Total benefits																														
Annual Running Costs:																														
Power Cost																														
Labor									6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800
Other																														
Other																														
Other																														
Other																														
Total running costs									**6,800**	**6,800**	**6,800**	**6,800**	**6,800**	**6,800**	**6,800**	**6,800**	**6,800**	**6,800**	**6,800**	**6,800**	**6,800**	**6,800**	**6,800**	**6,800**	**6,800**	**6,800**	**6,800**	**6,800**	**6,800**	**6,800**
R&R Costs:																														
General Repair and Replacement									1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
Other																														
Other																														
Other																														
Other																														
Total refurbishments									**1,200**	**1,200**	**1,200**	**1,200**	**1,200**	**1,200**	**1,200**	**1,200**	**1,200**	**1,200**	**1,200**	**1,200**	**1,200**	**1,200**	**1,200**	**1,200**	**1,200**	**1,200**	**1,200**	**1,200**	**1,200**	**1,200**
Net Benefit/(cost)			**(34,000)**	**(34,000)**	**(34,000)**	**(68,000)**	**(68,000)**	**(102,000)**	**(8,000)**	**(8,000)**	**(8,000)**	**(8,000)**	**(8,000)**	**(8,000)**	**(8,000)**	**(8,000)**	**(8,000)**	**(8,000)**	**(8,000)**	**(8,000)**	**(8,000)**	**(8,000)**	**(8,000)**	**(8,000)**	**(8,000)**	**(8,000)**	**(8,000)**	**(8,000)**	**(8,000)**	**(8,000)**
Expressed in escalated dollars with sensitivity adjustments																														
Capital Outlays																														
Construction - Alternative 1			36,071	37,153	38,267	78,831	81,196	125,447																						
Other																														
Other																														
Other																														
Total capital outlays			**36,071**	**37,153**	**38,267**	**78,831**	**81,196**	**125,447**																						
Benefits:																														
Other																														
Other																														
Other																														
Total benefits																														
Annual Running Costs:																														
Power Cost																														
Labor									8,614	8,872	9,139	9,413	9,695	9,986	10,286	10,594	10,912	11,239	11,577	11,924	12,282	12,650	13,030	13,420	13,823	14,238	14,665	15,105	15,558	16,025
Other																														
Other																														
Other																														
Other																														
Total running costs									**8,614**	**8,872**	**9,139**	**9,413**	**9,695**	**9,986**	**10,286**	**10,594**	**10,912**	**11,239**	**11,577**	**11,924**	**12,282**	**12,650**	**13,030**	**13,420**	**13,823**	**14,238**	**14,665**	**15,105**	**15,558**	**16,025**
R&R Costs:																														
General Repair and Replacement									1,520	1,566	1,613	1,661	1,711	1,762	1,815	1,870	1,926	1,983	2,043	2,104	2,167	2,232	2,299	2,368	2,439	2,513	2,588	2,666	2,746	2,828
Other																														
Other																														
Other																														
Other																														
Total refurbishments									**1,520**	**1,566**	**1,613**	**1,661**	**1,711**	**1,762**	**1,815**	**1,870**	**1,926**	**1,983**	**2,043**	**2,104**	**2,167**	**2,232**	**2,299**	**2,368**	**2,439**	**2,513**	**2,588**	**2,666**	**2,746**	**2,828**
Net escalated benefit/(cost)			**(36,071)**	**(37,153)**	**(38,267)**	**(78,831)**	**(81,196)**	**(125,447)**	**(10,134)**	**(10,438)**	**(10,751)**	**(11,074)**	**(11,406)**	**(11,748)**	**(12,101)**	**(12,464)**	**(12,838)**	**(13,223)**	**(13,619)**	**(14,028)**	**(14,449)**	**(14,882)**	**(15,329)**	**(15,789)**	**(16,262)**	**(16,750)**	**(17,253)**	**(17,770)**	**(18,303)**	**(18,853)**
Life cycle cost analysis																														
PVs in 2016			(34,670)	(35,010)	(35,353)	(71,399)	(72,099)	(109,209)	(8,649)	(8,734)	(8,820)	(8,906)	(8,994)	(9,082)	(9,171)	(9,261)	(9,352)	(9,443)	(9,536)	(9,629)	(9,724)	(9,819)	(9,915)	(10,012)	(10,111)	(10,210)	(10,310)	(10,411)	(10,513)	(10,616)
NPV as of 2016	**(568,958)**																													
	(570,000)																													

Total risk-adjusted capital outlays:	$340,000
Alternative:	1
Row:	8

Summary!A8	Alternative
Summary!B8	Alt. number
Summary!C8	Alt. name
Summary!E8	Risk premium
Summary!G8	Benefit sens.
Summary!H8	Capital sens
Summary!I8	Running sens.

From Summary Sheet:

Year of analysis	2016	**Benefits**	
Escalation rate	3.00%	**Capital costs**	
Discount rate	2.00%	**Running costs**	

Risk adjustments (+/- percent):

Inland Empire Utilities Agency

Life Cycle Alternative Cost Analysis ($000s)
Alternative 2

Year

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Expressed in 2016 dollars, unescalated															
Capital Outlays															
Construction - Alternative 2			108.000	108.000	108.000	216.000	216.000	324.000							
Other															
Other															
Other															
Total capital outlays			108,000	108,000	108,000	216,000	216,000	324,000							
Benefits:															
Other															
Other															
Other															
Total benefits															
Annual Running Costs:															
Power Cost									2.100	2.100	2.100	2.100	2.100	2.100	2.100
Labor									6.800	6.800	6.800	6.800	6.800	6.800	6.800
Other															
Other															
Other															
Other															
Total running costs									8,900	8,900	8,900	8,900	8,900	8,900	8,900
R&R Costs:															
General Repair and Replacement									21.900	21.900	21.900	21.900	21.900	21.900	21.900
Other															
Other															
Other															
Other															
Total refurbishments									21,900	21,900	21,900	21,900	21,900	21,900	21,900
Net Benefit/(cost)			(108,000)	(108,000)	(108,000)	(216,000)	(216,000)	(324,000)	(30,800)	(30,800)	(30,800)	(30,800)	(30,800)	(30,800)	(30,800)
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Construction - Alternative 2			114,577	118,015	121,555	250,403	257,915	398,479							
Other															
Other															
Other															
Total capital outlays			114,577	118,015	121,555	250,403	257,915	398,479							
Benefits:															
Other															
Other															
Other															
Total benefits															
Annual Running Costs:															
Power Cost									2,660	2,740	2,822	2,907	2,994	3,084	3,176
Labor									8.614	8.872	9.139	9.413	9.695	9.986	10.286
Other															
Other															
Other															
Other															
Total running costs									11,274	11,612	11,961	12,320	12,689	13,070	13,462
R&R Costs:															
General Repair and Replacement									27,742	28,575	29,432	30,315	31,224	32,161	33,126
Other															
Other															
Other															
Other															
Total refurbishments									27,742	28,575	29,432	30,315	31,224	32,161	33,126
Net escalated benefit/(cost)			(114,577)	(118,015)	(121,555)	(250,403)	(257,915)	(398,479)	(39,017)	(40,187)	(41,393)	(42,634)	(43,913)	(45,231)	(46,588)
Life cycle cost analysis															
PVs in 2016			(110,128)	(111,208)	(112,298)	(226,798)	(229,021)	(346,900)	(33,300)	(33,627)	(33,956)	(34,289)	(34,625)	(34,965)	(35,308)
NPV as of 2016	**(1,949,540)**														
	(1,950,000)														

	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Expressed in 2016 dollars, unescalated															
Capital Outlays															
Construction - Alternative 2															
Other															
Other															
Other															
Total capital outlays															
Benefits:															
Other															
Other															
Other															
Total benefits															
Annual Running Costs:															
Power Cost	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100
Labor	6.800	6.800	6.800	6.800	6.800	6.800	6.800	6.800	6.800	6.800	6.800	6.800	6.800	6.800	6.800
Other															
Other															
Other															
Other															
Total running costs	8,900	8,900	8,900	8,900	8,900	8,900	8,900	8,900	8,900	8,900	8,900	8,900	8,900	8,900	8,900
R&R Costs:															
General Repair and Replacement	21.900	21.900	21.900	21.900	21.900	21.900	21.900	21.900	21.900	21.900	21.900	21.900	21.900	21.900	21.900
Other															
Other															
Other															
Other															
Total refurbishments	21,900	21,900	21,900	21,900	21,900	21,900	21,900	21,900	21,900	21,900	21,900	21,900	21,900	21,900	21,900
Net Benefit/(cost)	(30,800)	(30,800)	(30,800)	(30,800)	(30,800)	(30,800)	(30,800)	(30,800)	(30,800)	(30,800)	(30,800)	(30,800)	(30,800)	(30,800)	(30,800)
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Construction - Alternative 2															
Other															
Other															
Other															
Total capital outlays															
Benefits:															
Other															
Other															
Other															
Total benefits															
Annual Running Costs:															
Power Cost	3,272	3,370	3,471	3,575	3,682	3,793	3,907	4,024	4,145	4,269	4,397	4,529	4,665	4,805	4,949
Labor	10.594	10.912	11.239	11.577	11.924	12.282	12.650	13.030	13.420	13.823	14.238	14.665	15.105	15.558	16.025
Other															
Other															
Other															
Other															
Total running costs	13,866	14,282	14,710	15,152	15,606	16,074	16,557	17,053	17,565	18,092	18,635	19,194	19,769	20,363	20,973
R&R Costs:															
General Repair and Replacement	34,119	35,143	36,197	37,283	38,402	39,554	40,740	41,963	43,222	44,518	45,854	47,229	48,646	50,106	51,609
Other															
Other															
Other															
Other															
Total refurbishments	34,119	35,143	36,197	37,283	38,402	39,554	40,740	41,963	43,222	44,518	45,854	47,229	48,646	50,106	51,609
Net escalated benefit/(cost)	(47,985)	(49,425)	(50,908)	(52,435)	(54,008)	(55,628)	(57,297)	(59,016)	(60,786)	(62,610)	(64,488)	(66,423)	(68,416)	(70,468)	(72,582)
Life cycle cost analysis															
PVs in 2016	(35,654)	(36,003)	(36,356)	(36,713)	(37,073)	(37,436)	(37,803)	(38,174)	(38,548)	(38,926)	(39,308)	(39,693)	(40,082)	(40,475)	(40,872)

Total risk-adjusted capital outlays: $1,080,000

Alternative: 1
Row: 8

Summary!A8	Alternative
Summary!B8	Alt. number
Summary!C8	Alt. name
Summary!E8	Risk premium
Summary!G8	Benefit sens.
Summary!H8	Capital sens
Summary!I8	Running sens.

Inland Empire Utilities Agency

Life Cycle Alternative Cost Analysis ($000s)
Alternative 3B

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2016	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	2.00%	Running costs	

Year

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Expressed in 2016 dollars, unescalated															
Capital Outlays															
Construction - Alternative 3			80.000	80.000	80.000	160.000	160.000	240.000							
Other															
Other															
Other															
Total capital outlays			80,000	80,000	80,000	160,000	160,000	240,000							
Benefits:															
Other															
Other															
Other															
Total benefits															
Annual Running Costs:															
Power Cost															
Labor									6.800	6.800	6.800	6.800	6.800	6.800	6.800
Other															
Other															
Other															
Other															
Total running costs									6,800	6,800	6,800	6,800	6,800	6,800	6,800
R&R Costs:															
General Repair and Replacement									2.400	2.400	2.400	2.400	2.400	2.400	2.400
Other															
Other															
Other															
Other															
Total refurbishments									2,400	2,400	2,400	2,400	2,400	2,400	2,400
Net Benefit/(cost)			(80,000)	(80,000)	(80,000)	(160,000)	(160,000)	(240,000)	(9,200)	(9,200)	(9,200)	(9,200)	(9,200)	(9,200)	(9,200)
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Construction - Alternative 2			84.872	87.418	90.041	185.484	191.048	295.170							
Other															
Other															
Other															
Total capital outlays			84,872	87,418	90,041	185,484	191,048	295,170							
Benefits:															
Other															
Other															
Other															
Total benefits															
Annual Running Costs:															
Power Cost															
Labor									8.614	8.872	9.139	9.413	9.695	9.986	10.286
Other															
Other															
Other															
Other															
Total running costs									8,614	8,872	9,139	9,413	9,695	9,986	10,286
R&R Costs:															
General Repair and Replacement									3,040	3,131	3,225	3,322	3,422	3,524	3,630
Other															
Other															
Other															
Other															
Total refurbishments									3,040	3,131	3,225	3,322	3,422	3,524	3,630
Net escalated benefit/(cost)			(84,872)	(87,418)	(90,041)	(185,484)	(191,048)	(295,170)	(11,654)	(12,004)	(12,364)	(12,735)	(13,117)	(13,511)	(13,916)
Life cycle cost analysis															
PVs in 2016			(81.576)	(82.376)	(83.184)	(167.998)	(169.645)	(256.963)	(9.947)	(10.044)	(10.143)	(10.242)	(10.343)	(10.444)	(10.546)
NPV as of 2016	(1,084,643)														
	(1.080.000)														

	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Expressed in 2016 dollars, unescalated															
Labor	6.800	6.800	6.800	6.800	6.800	6.800	6.800	6.800	6.800	6.800	6.800	6.800	6.800	6.800	6.800
Total running costs	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800
General Repair and Replacement	2.400	2.400	2.400	2.400	2.400	2.400	2.400	2.400	2.400	2.400	2.400	2.400	2.400	2.400	2.400
Total refurbishments	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400
Net Benefit/(cost)	(9,200)	(9,200)	(9,200)	(9,200)	(9,200)	(9,200)	(9,200)	(9,200)	(9,200)	(9,200)	(9,200)	(9,200)	(9,200)	(9,200)	(9,200)
Expressed in escalated dollars with sensitivity adjustments															
Labor	10.594	10.912	11.239	11.577	11.924	12.282	12.650	13.030	13.420	13.823	14.238	14.665	15.105	15.558	16.025
Total running costs	10,594	10,912	11,239	11,577	11,924	12,282	12,650	13,030	13,420	13,823	14,238	14,665	15,105	15,558	16,025
General Repair and Replacement	3,739	3,851	3,967	4,086	4,208	4,335	4,465	4,599	4,737	4,879	5,025	5,176	5,331	5,491	5,656
Total refurbishments	3,739	3,851	3,967	4,086	4,208	4,335	4,465	4,599	4,737	4,879	5,025	5,176	5,331	5,491	5,656
Net escalated benefit/(cost)	(14,333)	(14,763)	(15,206)	(15,662)	(16,132)	(16,616)	(17,115)	(17,628)	(18,157)	(18,702)	(19,263)	(19,841)	(20,436)	(21,049)	(21,680)
Life cycle cost analysis															
PVs in 2016	(10.650)	(10.754)	(10.860)	(10.966)	(11.074)	(11.182)	(11.292)	(11.403)	(11.514)	(11.627)	(11.741)	(11.856)	(11.973)	(12.090)	(12.209)

Total risk-adjusted capital outlays: $800.000

Alternative: 1
Row: 8

Summary!A8	Alternative
Summary!B8	Alt. number
Summary!C8	Alt. name
Summary!E8	Risk premium
Summary!G8	Benefit sens.
Summary!H8	Capital sens
Summary!I8	Running sens.

Alternative 1 - West of CCWRF Headworks Cost Estimate						
Item No.	**Description**	**No. of Items**	**Units**	**Quantity**	**Unit Cost ($)**	**Cost ($)**
	Piping					
1	8-inch Pipeline	120	ft	1	$ 192	$23,000
	STRUCTURES					
2	New IEBL Structures			1	$ 11,300	$11,300
3	Manhole			1	$ 4,800	$4,800
4	Excavation			1	$ 15,000	$15,000
5	Installation		%		15%	$2,415
	EQUIPMENT					
6	Equipment Relocation		LS	1	$10,000	$10,000
	CIVIL WORK					
7	Wall Demolition			1	$ 1,400	$1,400
8	Asphalt Paving			1	$ 68,000	$68,000
9	Restoration Driveway			1	$ 7,400	$7,400
10	Vegetation Removal			1	$ 10,500	$10,500
	SITE IMPROVEMENTS					
11	Security gate, card reader, bollards			1	$ 10,000	$10,000
12	Electrical & Instrumentation		%		15%	$1,500
	Total Equipment Cost					
	Subtotal of above items					**$165,000**
3.1	Sales Tax		%		9%	$4,400
	Construction Cost Estimate					**$170,000**

Alternative 2 - Northeast of RP-5 Cost Estimate						
Item No.	**Description**	**No. of Items**	**Units**	**Quantity**	**Unit Cost ($)**	**Cost ($)**
	Equipment					
1	4-inch Pipeline	2100	ft	1	$ 96	$202,000
2	8-inch Pipeline	300	ft	1	$ 192	$58,000
	LIFT STATION					
3	Lift Station - Pumps and Control Panel			2	$14,000	$28,000
	Equipment Installation			1	45%	$12,600
4	Wet well			1	$ 17,000	$17,000
	Excavation			1	$21,000	$21,000
	CONTROL PANEL					
5	Control Panel			1	$ 30,000	$ 30,000
	Installation		%		15%	$4,500
	STRUCTURES					
6	IEBL Structures			1	$ 11,300	$11,300
7	Manhole			1	$ 5,000	$5,000
	Installation			1	15%	$2,445
	Excavation			1	$ 17,000	$17,000
	CIVIL WORK					
8	Asphalt Paving			1	$ 89,000	$89,000
	SECURITY					
9	Security gate, card reader, bollards			1	$ 18,000	$18,000
10	Electrical & Instrumentation		%		15%	$2,700
	EQUIPMENT					
11	Equipment Relocation		LS	1	$10,000	$10,000
	Total Equipment Cost					
	Total Equipment and Structures Cost					**$529,000**
3.1	Sales Tax		%		9.000%	$17,100
	Construction Cost Estimate					**$546,000**

Alternative 3 - North of SHF Cost Estimate						
Item No.	**Description**	**No. of Items**	**Units**	**Quantity**	**Unit Cost ($)**	**Cost ($)**
	Piping					
1	8-inch Pipeline	750	ft	1	$ 192	$144,000
	STRUCTURES					
2	IEBL Structures			1	$ 11,300	$11,300
3	Manhole			1	$ 7,000	$7,000
	Installation			1	15%	$2,745
	Excavation			1	$ 15,000	$15,000
	CIVIL WORK					
4	Asphalt Paving			1	$ 186,000	$186,000
	SECURITY					
6	Security gate, card reader, bollards			1	$ 15,000	$15,000
	Electrical & Instrumentation		%		15%	$2,250
	EQUIPMENT					
7	Equipment Relocation		LS	1	$10,000	$10,000
	Total Equipment Cost					
	Subtotal of above items					**$393,000**
3.1	Sales Tax		%		9.000%	$11,000
	Construction Cost Estimate					**$404,000**

IEUA - Alternative 1 - O&M Costs

Item No.	Description	No. of Duty Units	Power Demand hp	Power Demand kW	Operating Hours/ year	kW-Hrs	Units	Unit Cost ($)	Annual Cost ($)
1	**Power**								
	Total power cost								**$ -**
Item No.	**Description**								
3	**Major Equipment Replacement**						**Units**	**Unit Cost ($)**	**Annual Cost ($)**
3.1	General Repair and Replacement						LS		1,200
	Total equipment replacement cost								**$ 1,200**
Item No.	**Description**				**Labor Hours / year**				
4	**Labor**						**Units**	**Unit Cost**	**Annual Cost ($)**
4.1					80		$/hr	85	6,800
	Total labor cost								**$ 6,800**
	TOTAL ANNUAL COST								**$ 8,000**

IEUA - Alternative 2 - O&M Costs

Item No.	Description	No. of Duty Units	Power Demand		Operating Hours/ year	kW-Hrs	Units	Unit Cost ($)	Annual Cost ($)
1	Power		hp	kW					
1.1	Influent Pumps	1	5.179674	3.86	4,380	16,924	$/kW-hr	0.125	2,116
	Total power cost								**$ 2,100**
Item No.	**Description**								
3	**Major Equipment Replacement**						**Units**	**Unit Cost ($)**	**Annual Cost ($)**
3.1	General Repair and Replacement						LS		21,869
	Total equipment replacement cost								**$ 21,900**
Item No.	**Description**				**Labor Hours / year**				
4	**Labor**						**Units**	**Unit Cost**	**Annual Cost ($)**
4.1					80		$/hr	85	6,800
	Total labor cost								**$ 6,800**
	TOTAL ANNUAL COST								**$ 30,800**

IEUA - Alternative 3 - O&M Costs

Item No.	Description	No. of Duty Units	Power Demand		Operating Hours/ year	kW-Hrs	Units	Unit Cost ($)	Annual Cost ($)
1	Power		hp	kW					
	Total power cost								**$ -**
Item No.	**Description**								
3	**Major Equipment Replacement**						**Units**	**Unit Cost ($)**	**Annual Cost ($)**
3.1	General Repair and Replacement						LS		2,400
	Total equipment replacement cost								**$ 2,400**
Item No.	**Description**				**Labor Hours / year**				
4	**Labor**						**Units**	**Unit Cost**	**Annual Cost ($)**
4.1					80		$/hr	85	6,800
	Total labor cost								**$ 6,800**
	TOTAL ANNUAL COST								**$ 9,200**

RP-5 Thickening

Inland Empire Utilities Agency
RP-5 (2016-22, 22-30, 30-45)
Alternatives Net Present Value Analysis

			Sensitivity Adjustments (%)			Results ($)		
Agency:	Inland Empire Utilities Agency	Risk Premium	Benefits	Capital Costs	Running Costs	Capital Cost	20-year NPV	Difference from Highest NPV
Project/Problem:	RP-5 (2016-22, 22-30, 30-45)							
Alternative 1	DAFT (WAS) and Centrifuges (PS)					$32,188,778	($62,353,741)	($35,971,238)
Alternative 2	DAFT (WAS) and RDT (PS)					$24,188,123	($45,720,340)	($19,337,836)
Alternative 3	DAFT (WAS) and GBT (PS)					$25,747,922	($49,119,992)	($22,737,489)
Alternative 4	Centrifuges Separate					$25,012,381	($50,211,462)	($23,828,958)
Alternative 5	Rotary Drum Thickener Separate					$12,784,464	($26,827,336)	($444,832)
Alternative 6	Gravity Belt Thickener Separate					$14,523,769	($32,591,733)	($6,209,230)
Alternative 7	DAFT Co-thickening					$19,047,354	($51,859,560)	($25,477,057)
Alternative 8	Centrifuges Co-thickening					$21,469,777	($46,737,780)	($20,355,277)
Alternative 9	Rotary Drum Thickener Co-thickening					$11,212,164	($26,382,504)	$0
Alternative 10	Gravity Belt Thickener Co-thickening					$11,850,933	($32,591,733)	($6,209,230)

Year of analysis:	2016
Escalation rate:	3.00%
Discount rate:	2.00%

Inland Empire Utilities Agency
RP-5 (2016-22, 22-30, 30-45)
Life Cycle Alternative Cost Analysis ($)
-

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2016	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

DAFT (WAS) and Centrifuges (PS)

Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Expressed in 2016 dollars, unescalated															
Capital Outlays															
Total Capital							32,188,778								
Total capital outlays	0	0	0	0	0	0	32,188,778	0	0	0	0	0	0	0	0
Benefits:															
Other															
Other															
Total benefits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:															
Energy Cost ($/year)								$246,903	$246,903	$373,001	$373,001	$373,001	$373,001	$373,001	$493,805
Total Polymer Cost ($/year)								$176,459	$178,978	$181,496	$187,847	$194,198	$200,549	$206,900	$213,251
Annual Water Cost ($/year)								$26,313	$26,313	$29,493	$29,493	$29,493	$29,493	$29,493	$35,276
Maintenance Labor Cost ($/year)								$64,218	$64,218	$77,367	$77,367	$77,367	$77,367	$77,367	$128,436
Operational Labor Cost ($/year)								$43,321	$43,321	$69,619	$69,619	$69,619	$69,619	$69,619	$86,642
Odor Control								$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000
Other															
Other															
Total running costs	0	0	0	0	0	0	0	590,213	592,732	763,977	770,328	776,679	783,030	789,381	990,411
R&R Costs:															
Total Annual Repair and Replacement Cost								10,970	12,245	31,312	20,636	40,155	28,017	29,774	31,870
Other															
Other															
Other															
Other															
Total refurbishments		0	0	0	0	0	0	10,970	12,245	31,312	20,636	40,155	28,017	29,774	31,870
Net Benefit/(cost)	0	0	0	0	0	0	(32,188,778)	(601,184)	(604,976)	(795,289)	(790,964)	(816,834)	(811,047)	(819,155)	(1,022,281)
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Total Capital	0	0	0	0	0	0	38,435,085	0	0	0	0	0	0	0	0
Total capital outlays	0	0	0	0	0	0	38,435,085	0	0	0	0	0	0	0	0
Benefits:															
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:															
Energy Cost ($/year)	0	0	0	0	0	0	0	303,659	312,769	486,682	501,283	516,321	531,811	547,765	746,925
Total Polymer Cost ($/year)	0	0	0	0	0	0	0	217,023	226,724	236,811	252,451	268,816	285,935	303,840	322,562
Annual Water Cost ($/year)	0	0	0	0	0	0	0	32,361	33,332	38,482	39,637	40,826	42,050	43,312	53,359
Maintenance Labor Cost ($/year)	0	0	0	0	0	0	0	78,980	81,349	100,946	103,975	107,094	110,307	113,616	194,270
Operational Labor Cost ($/year)	0	0	0	0	0	0	0	53,279	54,878	90,837	93,562	96,369	99,260	102,238	131,054
Odor Control	0	0	0	0	0	0	0	40,586	41,803	43,058	44,349	45,680	47,050	48,462	49,915
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	0	0	0	0	0	0	0	725,888	750,855	996,817	1,035,256	1,075,105	1,116,413	1,159,233	1,498,085
R&R Costs:															
Total Annual Repair and Replacement Cost	0	0	0	0	0	0	0	13,492	15,511	40,855	27,733	55,584	39,945	43,724	48,206
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	0	0	0	0	0	0	0	13,492	15,511	40,855	27,733	55,584	39,945	43,724	48,206
Net escalated benefit/(cost)	0	0	0	0	0	0	(38,435,085)	(739,380)	(766,366)	(1,037,671)	(1,062,989)	(1,130,689)	(1,156,359)	(1,202,957)	(1,546,291)
Life cycle cost analysis															
PVs in 2016	0	0	0	0	0	0	(34,129,255)	(643,675)	(654,086)	(868,277)	(872,021)	(909,371)	(911,781)	(929,925)	(1,171,895)
NPV as of 2016	(62,353,741)														

Year	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Expressed in 2016 dollars, unescalated															
Capital Outlays															
Total Capital															
Total capital outlays	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benefits:															
							0								
Other															
Other															
Total benefits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:															
Energy Cost ($/year)	$493,805	$493,805	$493,805	$493,805	$493,805	$493,805	$493,805	$493,805	$493,805	$493,805	$493,805	$493,805	$493,805	$493,805	$493,805
Total Polymer Cost ($/year)	$217,084	$220,916	$224,749	$228,581	$232,414	$236,630	$240,845	$245,061	$249,277	$253,493	$256,668	$259,844	$263,019	$266,195	$269,370
Annual Water Cost ($/year)	$35,276	$35,276	$35,276	$35,276	$35,276	$35,276	$35,276	$35,276	$35,276	$35,276	$35,276	$35,276	$35,276	$35,276	$35,276
Maintenance Labor Cost ($/year)	$128,436	$128,436	$128,436	$128,436	$128,436	$128,436	$128,436	$128,436	$128,436	$128,436	$128,436	$128,436	$128,436	$128,436	$128,436
Operational Labor Cost ($/year)	$86,642	$86,642	$86,642	$86,642	$86,642	$86,642	$86,642	$86,642	$86,642	$86,642	$86,642	$86,642	$86,642	$86,642	$86,642
Odor Control	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000
Other															
Other															
Total running costs	994,243	998,076	1,001,908	1,005,741	1,009,573	1,013,789	1,018,005	1,022,220	1,026,436	1,030,652	1,033,827	1,037,003	1,040,178	1,043,354	1,046,529
R&R Costs:															
Total Annual Repair and Replacement Cost	41,008	29,489	48,389	26,215	36,439	93,146	33,989	98,989	36,870	33,627	31,870	46,008	24,489	1,142,137	23,215
Other															
Other															
Other															
Other															
Total refurbishments	41,008	29,489	48,389	26,215	36,439	93,146	33,989	98,989	36,870	33,627	31,870	46,008	24,489	1,142,137	23,215
Net Benefit/(cost)	(1,035,251)	(1,027,565)	(1,050,297)	(1,031,956)	(1,046,012)	(1,106,935)	(1,051,994)	(1,121,210)	(1,063,306)	(1,064,279)	(1,065,697)	(1,083,011)	(1,064,667)	(2,185,490)	(1,069,744)
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Total Capital	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benefits:															
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:															
Energy Cost ($/year)	769,333	792,413	816,185	840,671	865,891	891,868	918,624	946,182	974,568	1,003,805	1,033,919	1,064,937	1,096,885	1,129,791	1,163,685
Total Polymer Cost ($/year)	338,209	354,506	371,475	389,144	407,539	427,379	448,043	469,562	491,969	515,298	537,406	560,376	584,241	609,034	634,788
Annual Water Cost ($/year)	54,959	56,608	58,306	60,056	61,857	63,713	65,624	67,593	69,621	71,710	73,861	76,077	78,359	80,710	83,131
Maintenance Labor Cost ($/year)	200,098	206,101	212,284	218,653	225,213	231,969	238,928	246,096	253,479	261,083	268,916	276,983	285,293	293,851	302,667
Operational Labor Cost ($/year)	134,985	139,035	143,206	147,502	151,927	156,485	161,180	166,015	170,996	176,125	181,409	186,851	192,457	198,231	204,178
Odor Control	51,413	52,955	54,544	56,180	57,866	59,602	61,390	63,231	65,128	67,082	69,095	71,168	73,303	75,502	77,767
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	1,548,998	1,601,618	1,656,001	1,712,206	1,770,293	1,831,015	1,893,788	1,958,680	2,025,761	2,095,103	2,164,605	2,236,391	2,310,537	2,387,118	2,466,215
R&R Costs:															
Total Annual Repair and Replacement Cost	63,889	47,321	79,979	44,629	63,896	168,232	63,230	189,674	72,766	68,357	66,728	99,220	54,397	2,613,126	54,707
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	63,889	47,321	79,979	44,629	63,896	168,232	63,230	189,674	72,766	68,357	66,728	99,220	54,397	2,613,126	54,707
Net escalated benefit/(cost)	(1,612,888)	(1,648,940)	(1,735,981)	(1,756,835)	(1,834,189)	(1,999,248)	(1,957,018)	(2,148,354)	(2,098,526)	(2,163,460)	(2,231,333)	(2,335,612)	(2,364,934)	(5,000,244)	(2,520,923)
Life cycle cost analysis															
PVs in 2016	(1,198,399)	(1,201,163)	(1,239,773)	(1,230,065)	(1,259,043)	(1,345,436)	(1,291,193)	(1,389,639)	(1,330,793)	(1,345,070)	(1,360,067)	(1,395,713)	(1,385,525)	(2,872,013)	(1,419,563)

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2016	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

Inland Empire Utilities Agency
RP-5 (2016-22, 22-30, 30-45)
Life Cycle Alternative Cost Analysis ($)
-

	Year																													
DAFT (WAS) and RDT (PS)	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Expressed in 2016 dollars, unescalated																														
Capital Outlays																														
Total Capital							24,188,123																							
Total capital outlays	0	0	0	0	0	0	24,188,123	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benefits:																														
																						0								
Other																														
Other																														
Total benefits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:																														
Energy Cost ($/year)								$134,634	$134,634	$134,634	$134,634	$134,634	$134,634	$134,634	$255,438	$255,438	$255,438	$255,438	$255,438	$255,438	$255,438	$255,438	$255,438	$255,438	$255,438	$255,438	$255,438	$255,438	$255,438	$255,438
Total Polymer Cost ($/year)								$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459
Annual Water Cost ($/year)								$52,047	$52,047	$52,047	$52,047	$52,047	$52,047	$52,047	$57,830	$57,830	$57,830	$57,830	$57,830	$57,830	$57,830	$57,830	$57,830	$57,830	$57,830	$57,830	$57,830	$57,830	$57,830	$57,830
Maintenance Labor Cost ($/year)								$77,367	$77,367	$77,367	$77,367	$77,367	$77,367	$77,367	$128,436	$128,436	$128,436	$128,436	$128,436	$128,436	$128,436	$128,436	$128,436	$128,436	$128,436	$128,436	$128,436	$128,436	$128,436	$128,436
Operational Labor Cost ($/year)								$69,619	$69,619	$69,619	$69,619	$69,619	$69,619	$69,619	$86,642	$86,642	$86,642	$86,642	$86,642	$86,642	$86,642	$86,642	$86,642	$86,642	$86,642	$86,642	$86,642	$86,642	$86,642	$86,642
Odor Control								$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000
Other																														
Other																														
Total running costs	0	0	0	0	0	0	0	543,126	543,126	543,126	543,126	543,126	543,126	543,126	737,805	737,805	737,805	737,805	737,805	737,805	737,805	737,805	737,805	737,805	737,805	737,805	737,805	737,805	737,805	737,805
R&R Costs:																														
Total Annual Repair and Replacement Cost								10,754	10,754	10,754	10,754	13,754	10,754	10,754	14,607	14,607	19,607	14,607	17,607	14,607	14,607	50,802	14,607	19,607	14,607	14,607	19,607	14,607	673,355	14,607
Other																														
Other																														
Other																														
Other																														
Total refurbishments		0	0	0	0	0	0	10,754	10,754	10,754	10,754	13,754	10,754	10,754	14,607	14,607	19,607	14,607	17,607	14,607	14,607	50,802	14,607	19,607	14,607	14,607	19,607	14,607	673,355	14,607
Net Benefit/(cost)	0	0	0	0	0	0	(24,188,123)	(553,881)	(553,881)	(553,881)	(553,881)	(556,881)	(553,881)	(553,881)	(752,412)	(752,412)	(757,412)	(752,412)	(755,412)	(752,412)	(752,412)	(788,607)	(752,412)	(757,412)	(752,412)	(752,412)	(757,412)	(752,412)	(1,411,160)	(752,412)
Expressed in escalated dollars with sensitivity adjustments																														
Capital Outlays																														
Total Capital	0	0	0	0	0	0	28,881,884	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	0	0	0	0	0	0	28,881,884	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benefits:																														
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:																														
Energy Cost ($/year)	0	0	0	0	0	0	0	165,583	170,551	175,667	180,937	186,365	191,956	197,715	386,373	397,964	409,903	422,200	434,866	447,912	461,350	475,190	489,446	504,129	519,253	534,831	550,876	567,402	584,424	601,957
Total Polymer Cost ($/year)	0	0	0	0	0	0	0	217,023	223,533	230,239	237,146	244,261	251,589	259,136	266,910	274,918	283,165	291,660	300,410	309,422	318,705	328,266	338,114	348,258	358,705	369,466	380,550	391,967	403,726	415,838
Annual Water Cost ($/year)	0	0	0	0	0	0	0	64,011	65,932	67,910	69,947	72,045	74,207	76,433	87,473	90,097	92,800	95,584	98,452	101,405	104,448	107,581	110,808	114,133	117,557	121,083	124,716	128,457	132,311	136,280
Maintenance Labor Cost ($/year)	0	0	0	0	0	0	0	95,151	98,006	100,946	103,975	107,094	110,307	113,616	194,270	200,098	206,101	212,284	218,653	225,213	231,969	238,928	246,096	253,479	261,083	268,916	276,983	285,293	293,851	302,667
Operational Labor Cost ($/year)	0	0	0	0	0	0	0	85,623	88,191	90,837	93,562	96,369	99,260	102,238	131,054	134,985	139,035	143,206	147,502	151,927	156,485	161,180	166,015	170,996	176,125	181,409	186,851	192,457	198,231	204,178
Odor Control	0	0	0	0	0	0	0	40,586	41,803	43,058	44,349	45,680	47,050	48,462	49,915	51,413	52,955	54,544	56,180	57,866	59,602	61,390	63,231	65,128	67,082	69,095	71,168	73,303	75,502	77,767
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	0	0	0	0	0	0	0	667,977	688,016	708,657	729,917	751,814	774,368	797,599	1,115,996	1,149,476	1,183,961	1,219,479	1,256,064	1,293,746	1,332,558	1,372,535	1,413,711	1,456,122	1,499,806	1,544,800	1,591,144	1,638,878	1,688,045	1,738,686
R&R Costs:																														
Total Annual Repair and Replacement Cost	0	0	0	0	0	0	0	13,226	13,623	14,032	14,453	19,039	15,333	15,793	22,095	22,758	31,464	24,144	29,975	25,614	26,383	94,507	27,989	38,697	29,694	30,585	42,285	32,447	1,540,588	34,423
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	0	0	0	0	0	0	0	13,226	13,623	14,032	14,453	19,039	15,333	15,793	22,095	22,758	31,464	24,144	29,975	25,614	26,383	94,507	27,989	38,697	29,694	30,585	42,285	32,447	1,540,588	34,423
Net escalated benefit/(cost)	0	0	0	0	0	0	(28,881,884)	(681,203)	(701,639)	(722,689)	(744,369)	(770,853)	(789,701)	(813,392)	(1,138,091)	(1,172,234)	(1,215,425)	(1,243,623)	(1,286,039)	(1,319,360)	(1,358,941)	(1,467,042)	(1,441,700)	(1,494,819)	(1,529,500)	(1,575,385)	(1,633,429)	(1,671,326)	(3,228,632)	(1,773,109)
Life cycle cost analysis																														
PVs in 2016	0	0	0	0	0	0	(25,646,287)	(593,028)	(598,842)	(604,713)	(610,642)	(619,969)	(622,674)	(628,779)	(862,531)	(870,987)	(885,371)	(888,149)	(900,432)	(905,649)	(914,528)	(967,919)	(932,548)	(947,948)	(950,923)	(960,246)	(976,103)	(979,166)	(1,854,444)	(998,460)
NPV as of 2016	(45,720,340)																													

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2016	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

Inland Empire Utilities Agency
RP-5 (2016-22, 22-30, 30-45)
Life Cycle Alternative Cost Analysis ($)
-

AFT (WAS) and GBT (PS)

	Year																													
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
xpressed in 2016 dollars, unescalated																														
apital Outlays																														
Total Capital							25,747,922																							
Total capital outlays	0	0	0	0	0	0	25,747,922	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
enefits:																														
Other																														
Other																														
Other																														
Total benefits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
nnual Running Costs:																														
Energy Cost ($/year)								$130,567	$130,567	$130,567	$130,567	$130,567	$130,567	$130,567	$251,371	$251,371	$251,371	$251,371	$251,371	$251,371	$251,371	$251,371	$251,371	$251,371	$261,133	$261,133	$261,133	$261,133	$261,133	$261,133
Total Polymer Cost ($/year)								$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459	$176,459
Annual Water Cost ($/year)								$60,722	$60,722	$60,722	$60,722	$60,722	$60,722	$60,722	$66,505	$66,505	$66,505	$66,505	$66,505	$66,505	$66,505	$66,505	$66,505	$66,505	$104,094	$104,094	$104,094	$104,094	$104,094	$104,094
Maintenance Labor Cost ($/year)								77,367	77,367	77,367	77,367	77,367	77,367	77,367	128,436	128,436	128,436	128,436	128,436	128,436	128,436	128,436	128,436	128,436	154,734	154,734	154,734	154,734	154,734	154,734
Operational Labor Cost ($/year)								69,619	69,619	69,619	69,619	69,619	69,619	69,619	86,642	86,642	86,642	86,642	86,642	86,642	86,642	86,642	86,642	86,642	139,238	139,238	139,238	139,238	139,238	139,238
Odor Control								33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000
Total running costs			0	0	0	0	0	547,733	547,733	547,733	547,733	547,733	547,733	547,733	742,412	742,412	742,412	742,412	742,412	742,412	742,412	742,412	742,412	742,412	868,658	868,658	868,658	868,658	868,658	868,658
&R Costs:																														
Total Annual Repair and Replacement Cost					0	0	0	26,965	26,965	31,886	26,965	34,886	26,965	31,886	30,818	35,739	35,818	40,206	33,818	35,739	30,818	45,239	30,818	40,739	30,818	35,739	35,818	35,739	807,533	35,739
Other																														
Other																														
Other																														
Other																														
Total refurbishments		0	0	0	0	0	0	26,965	26,965	31,886	26,965	34,886	26,965	31,886	30,818	35,739	35,818	40,206	33,818	35,739	30,818	45,239	30,818	40,739	30,818	35,739	35,818	35,739	807,533	35,739
et Benefit/(cost)	0	0	0	0	0	0	(25,747,922)	(574,698)	(574,698)	(579,619)	(574,698)	(582,619)	(574,698)	(579,619)	(773,230)	(778,151)	(778,230)	(782,618)	(776,230)	(778,151)	(773,230)	(787,651)	(773,230)	(783,151)	(899,476)	(904,397)	(904,476)	(904,397)	(1,676,191)	(904,397)
xpressed in escalated dollars with sensitivity adjustments																														
apital Outlays																														
Total Capital	0	0	0	0	0	0	30,744,365	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	0	0	0	0	0	0	30,744,365	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
enefits:																														
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
nnual Running Costs:																														
Energy Cost ($/year)	0	0	0	0	0	0	0	160,580	165,398	170,360	175,470	180,735	186,157	191,741	380,220	391,627	403,376	415,477	427,942	440,780	454,003	467,623	481,652	496,101	530,830	546,755	563,157	580,052	597,453	615,377
Total Polymer Cost ($/year)	0	0	0	0	0	0	0	217,023	223,533	230,239	237,146	244,261	251,589	259,136	266,910	274,918	283,165	291,660	300,410	309,422	318,705	328,266	338,114	348,258	358,705	369,466	380,550	391,967	403,726	415,838
Annual Water Cost ($/year)	0	0	0	0	0	0	0	74,680	76,920	79,228	81,605	84,053	86,574	89,172	100,594	103,612	106,720	109,922	113,220	116,616	120,115	123,718	127,430	131,253	211,602	217,950	224,488	231,223	238,160	245,305
Maintenance Labor Cost ($/year)	0	0	0	0	0	0	0	95,151	98,006	100,946	103,975	107,094	110,307	113,616	194,270	200,098	206,101	212,284	218,653	225,213	231,969	238,928	246,096	253,479	314,542	323,978	333,697	343,708	354,019	364,640
Operational Labor Cost ($/year)	0	0	0	0	0	0	0	85,623	88,191	90,837	93,562	96,369	99,260	102,238	131,054	134,985	139,035	143,206	147,502	151,927	156,485	161,180	166,015	170,996	283,043	291,534	300,280	309,288	318,567	328,124
Odor Control	0	0	0	0	0	0	0	40,586	41,803	43,058	44,349	45,680	47,050	48,462	49,915	51,413	52,955	54,544	56,180	57,866	59,602	61,390	63,231	65,128	67,082	69,095	71,168	73,303	75,502	77,767
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	0	0	0	0	0	0	0	673,643	693,852	714,668	736,108	758,191	780,937	804,365	1,122,965	1,156,654	1,191,353	1,227,094	1,263,907	1,301,824	1,340,879	1,381,105	1,422,538	1,465,214	1,765,803	1,818,777	1,873,341	1,929,541	1,987,427	2,047,050
&R Costs:																														
Total Annual Repair and Replacement Cos	0	0	0	0	0	0	0	33,163	34,158	41,603	36,239	48,290	38,446	46,825	46,615	55,680	57,478	66,454	57,573	62,668	55,661	84,157	59,051	80,401	62,647	74,829	77,245	79,386	1,847,577	84,221
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	0	0	0	0	0	0	0	33,163	34,158	41,603	36,239	48,290	38,446	46,825	46,615	55,680	57,478	66,454	57,573	62,668	55,661	84,157	59,051	80,401	62,647	74,829	77,245	79,386	1,847,577	84,221
et escalated benefit/(cost)	0	0	0	0	0	0	(30,744,365)	(706,806)	(728,010)	(756,271)	(772,346)	(806,481)	(819,382)	(851,190)	(1,169,580)	(1,212,333)	(1,248,831)	(1,293,548)	(1,321,480)	(1,364,492)	(1,396,540)	(1,465,262)	(1,481,589)	(1,545,616)	(1,828,450)	(1,893,606)	(1,950,586)	(2,008,927)	(3,835,004)	(2,131,271)
ife cycle cost analysis																														
Vs in 2016	0	0	0	0	0	0	(27,300,117)	(615,317)	(621,350)	(632,814)	(633,593)	(648,623)	(646,077)	(657,997)	(886,395)	(900,782)	(909,706)	(923,804)	(925,246)	(936,629)	(939,831)	(966,745)	(958,349)	(980,161)	(1,136,787)	(1,154,212)	(1,165,630)	(1,176,954)	(2,202,729)	(1,200,145)
PV as of 2016	(49,119,992)																													

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2016	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

Inland Empire Utilities Agency
RP-5 (2016-22, 22-30, 30-45)
Life Cycle Alternative Cost Analysis ($)
-

Centrifuges Separate

Year

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Expressed in 2016 dollars, unescalated										
Capital Outlays										
Total capital							25,012,381			
Total capital outlays	0	0	0	0	0	0	25,012,381	0	0	0
Benefits:										
Other										
Other										
Total benefits	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:										
Energy Cost ($/year)								$252,197	$252,197	$378,296
Total Polymer Cost ($/year)								$239,586	$239,586	$239,586
Annual Water Cost ($/year)								$29,493	$29,493	$35,565
Maintenance Labor Cost ($/year)								$30,681	$30,681	$43,830
Operational Labor Cost ($/year)								$52,596	$52,596	$78,894
Odor Control								$23,500	$23,500	$23,500
Other										
Other										
Total running costs	0	0	0	0	0	0	0	628,054	628,054	799,672
R&R Costs:										
Total Annual Repair and Replacement Cost								21,352	25,174	61,024
Other										
Other										
Other										
Other										
Total refurbishments		0	0	0	0	0	0	21,352	25,174	61,024
Net Benefit/(cost)	0	0	0	0	0	0	(25,012,381)	(649,406)	(653,228)	(860,696)
Expressed in escalated dollars with sensitivity adjustments										
Capital Outlays										
Total capital	0	0	0	0	0	0	29,866,091	0	0	0
Total capital outlays	0	0	0	0	0	0	29,866,091	0	0	0
Benefits:										
0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0
Total benefits	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:										
Energy Cost ($/year)	0	0	0	0	0	0	0	310,171	319,476	493,591
Total Polymer Cost ($/year)	0	0	0	0	0	0	0	294,661	303,500	312,605
Annual Water Cost ($/year)	0	0	0	0	0	0	0	36,273	37,361	46,405
Maintenance Labor Cost ($/year)	0	0	0	0	0	0	0	37,734	38,866	57,188
Operational Labor Cost ($/year)	0	0	0	0	0	0	0	64,687	66,627	102,939
Odor Control	0	0	0	0	0	0	0	28,902	29,769	30,662
Other	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0
Total running costs	0	0	0	0	0	0	0	772,427	795,600	1,043,391
R&R Costs:										
Total Annual Repair and Replacement Cost	0	0	0	0	0	0	0	26,260	31,890	79,622
Other	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0
Other		0	0	0	0	0	0	0	0	0
Total refurbishments	0	0	0	0	0	0	0	26,260	31,890	79,622
Net escalated benefit/(cost)	0	0	0	0	0	0	(29,866,091)	(798,687)	(827,490)	(1,123,013)
Life cycle cost analysis										
PVs in 2016	0	0	0	0	0	0	(26,520,234)	(695,305)	(706,254)	(939,687)
NPV as of 2016	(50,211,462)									

	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Expressed in 2016 dollars, unescalated										
Capital Outlays										
Total capital										
Total capital outlays	0	0	0	0	0	0	0	0	0	0
Benefits:										
Other										
Other										
Total benefits	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:										
Energy Cost ($/year)	$378,296	$378,296	$378,296	$378,296	$378,296	$378,296	$378,296	$378,296	$378,296	$378,296
Total Polymer Cost ($/year)	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586
Annual Water Cost ($/year)	$35,565	$35,565	$35,565	$35,565	$35,565	$35,565	$35,565	$35,565	$35,565	$35,565
Maintenance Labor Cost ($/year)	$43,830	$43,830	$43,830	$43,830	$43,830	$43,830	$43,830	$43,830	$43,830	$43,830
Operational Labor Cost ($/year)	$78,894	$78,894	$78,894	$78,894	$78,894	$78,894	$78,894	$78,894	$78,894	$78,894
Odor Control	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500
Other										
Other										
Total running costs	799,672	799,672	799,672	799,672	799,672	799,672	799,672	799,672	799,672	799,672
R&R Costs:										
Total Annual Repair and Replacement Cost	25,174	38,881	47,317	38,881	25,174	61,024	25,174	61,024	21,352	25,174
Other										
Other										
Other										
Other										
Total refurbishments	25,174	38,881	47,317	38,881	25,174	61,024	25,174	61,024	21,352	25,174
Net Benefit/(cost)	(824,846)	(838,553)	(846,989)	(838,553)	(824,846)	(860,696)	(824,846)	(860,696)	(821,024)	(824,846)
Expressed in escalated dollars with sensitivity adjustments										
Capital Outlays										
Total capital	0	0	0	0	0	0	0	0	0	0
Total capital outlays	0	0	0	0	0	0	0	0	0	0
Benefits:										
0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0
Total benefits	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:										
Energy Cost ($/year)	508,398	523,650	539,360	555,541	572,207	589,373	607,054	625,266	644,024	663,345
Total Polymer Cost ($/year)	321,984	331,643	341,592	351,840	362,395	373,267	384,465	395,999	407,879	420,116
Annual Water Cost ($/year)	47,797	49,231	50,708	52,229	53,796	55,410	57,072	58,784	60,548	62,364
Maintenance Labor Cost ($/year)	58,904	60,671	62,491	64,366	66,297	68,286	70,335	72,445	74,618	76,856
Operational Labor Cost ($/year)	106,027	109,208	112,484	115,859	119,335	122,915	126,602	130,400	134,312	138,342
Odor Control	31,582	32,529	33,505	34,511	35,546	36,612	37,711	38,842	40,007	41,207
Other	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0
Total running costs	1,074,692	1,106,933	1,140,141	1,174,345	1,209,576	1,245,863	1,283,239	1,321,736	1,361,388	1,402,230
R&R Costs:										
Total Annual Repair and Replacement Cost	33,832	53,820	67,462	57,098	38,078	95,073	40,397	100,863	36,350	44,143
Other	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0
Total refurbishments	33,832	53,820	67,462	57,098	38,078	95,073	40,397	100,863	36,350	44,143
Net escalated benefit/(cost)	(1,108,524)	(1,160,754)	(1,207,603)	(1,231,443)	(1,247,653)	(1,340,936)	(1,323,636)	(1,422,599)	(1,397,738)	(1,446,372)
Life cycle cost analysis										
PVs in 2016	(909,376)	(933,551)	(952,187)	(951,946)	(945,565)	(996,335)	(964,197)	(1,015,967)	(978,639)	(992,834)

	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Expressed in 2016 dollars, unescalated										
Capital Outlays										
Total capital										
Total capital outlays	0	0	0	0	0	0	0	0	0	0
Benefits:										
		0								
Other										
Other										
Total benefits	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:										
Energy Cost ($/year)	$378,296	$378,296	$378,296	$378,296	$378,296	$378,296	$378,296	$378,296	$378,296	$378,296
Total Polymer Cost ($/year)	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586
Annual Water Cost ($/year)	$35,565	$35,565	$35,565	$35,565	$35,565	$35,565	$35,565	$35,565	$35,565	$35,565
Maintenance Labor Cost ($/year)	$43,830	$43,830	$43,830	$43,830	$43,830	$43,830	$43,830	$43,830	$43,830	$43,830
Operational Labor Cost ($/year)	$78,894	$78,894	$78,894	$78,894	$78,894	$78,894	$78,894	$78,894	$78,894	$78,894
Odor Control	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500
Other										
Other										
Total running costs	799,672	799,672	799,672	799,672	799,672	799,672	799,672	799,672	799,672	799,672
R&R Costs:										
Total Annual Repair and Replacement Cost	234,968	25,174	38,881	47,317	38,881	25,174	61,024	25,174	688,336	21,352
Other										
Other										
Other										
Other										
Total refurbishments	234,968	25,174	38,881	47,317	38,881	25,174	61,024	25,174	688,336	21,352
Net Benefit/(cost)	(1,034,640)	(824,846)	(838,553)	(846,989)	(838,553)	(824,846)	(860,696)	(824,846)	(1,488,008)	(821,024)
Expressed in escalated dollars with sensitivity adjustments										
Capital Outlays										
Total capital	0	0	0	0	0	0	0	0	0	0
Total capital outlays	0	0	0	0	0	0	0	0	0	0
Benefits:										
0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0
Total benefits	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:										
Energy Cost ($/year)	683,245	703,742	724,854	746,600	768,998	792,068	815,830	840,305	865,514	891,480
Total Polymer Cost ($/year)	432,719	445,701	459,072	472,844	487,029	501,640	516,689	532,190	548,155	564,600
Annual Water Cost ($/year)	64,235	66,162	68,147	70,192	72,297	74,466	76,700	79,001	81,371	83,812
Maintenance Labor Cost ($/year)	79,162	81,537	83,983	86,503	89,098	91,771	94,524	97,359	100,280	103,289
Operational Labor Cost ($/year)	142,492	146,767	151,170	155,705	160,376	165,187	170,143	175,247	180,504	185,920
Odor Control	42,444	43,717	45,028	46,379	47,771	49,204	50,680	52,200	53,766	55,379
Other	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0
Total running costs	1,444,297	1,487,625	1,532,254	1,578,222	1,625,569	1,674,336	1,724,566	1,776,303	1,829,592	1,884,479
R&R Costs:										
Total Annual Repair and Replacement Cost	424,377	46,831	74,500	93,383	79,037	52,709	131,603	55,919	1,574,862	50,317
Other	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0
Total refurbishments	424,377	46,831	74,500	93,383	79,037	52,709	131,603	55,919	1,574,862	50,317
Net escalated benefit/(cost)	(1,868,674)	(1,534,456)	(1,606,754)	(1,671,605)	(1,704,606)	(1,727,044)	(1,856,169)	(1,832,221)	(3,404,454)	(1,934,796)
Life cycle cost analysis										
PVs in 2016	(1,257,564)	(1,012,397)	(1,039,311)	(1,060,058)	(1,059,790)	(1,052,687)	(1,109,208)	(1,073,429)	(1,955,432)	(1,089,507)

Inland Empire Utilities Agency
RP-5 (2016-22, 22-30, 30-45)
Life Cycle Alternative Cost Analysis ($)
-

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2016	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

Rotary Drum Thickener Separate

Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Expressed in 2016 dollars, unescalated															
Capital Outlays															
Total							12,784,464								
Total capital outlays	0	0	0	0	0	0	12,784,464	0	0	0	0	0	0	0	0
Benefits:															
Other															
Other															
Total benefits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:															
Energy Cost ($/year)								$20,745	$20,745	$20,745	$20,745	$20,745	$20,745	$20,745	$20,745
Total Polymer Cost ($/year)								$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586
Annual Water Cost ($/year)								$46,264	$46,264	$60,722	$60,722	$60,722	$60,722	$60,722	$60,722
Maintenance Labor Cost ($/year)								$39,447	$39,447	$39,447	$39,447	$39,447	$39,447	$39,447	$39,447
Operational Labor Cost ($/year)								$78,894	$78,894	$78,894	$78,894	$78,894	$78,894	$78,894	$78,894
Odor Control								$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500
Other															
Other															
Total running costs	0	0	0	0	0	0	0	448,437	448,437	462,894	462,894	462,894	462,894	462,894	462,894
R&R Costs:															
Total Annual Repair and Replacement Cost								10,351	10,351	10,351	10,351	10,351	10,351	10,351	10,351
Other															
Other															
Other															
Other															
Total refurbishments		0	0	0	0	0	0	10,351	10,351	10,351	10,351	10,351	10,351	10,351	10,351
Net Benefit/(cost)	0	0	0	0	0	0	(12,784,464)	(458,788)	(458,788)	(473,246)	(473,246)	(473,246)	(473,246)	(473,246)	(473,246)
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Total	0	0	0	0	0	0	15,265,319	0	0	0	0	0	0	0	0
Total capital outlays	0	0	0	0	0	0	15,265,319	0	0	0	0	0	0	0	0
Benefits:															
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:															
Energy Cost ($/year)	0	0	0	0	0	0	0	25,514	26,279	27,068	27,880	28,716	29,578	30,465	31,379
Total Polymer Cost ($/year)	0	0	0	0	0	0	0	294,661	303,500	312,605	321,984	331,643	341,592	351,840	362,395
Annual Water Cost ($/year)	0	0	0	0	0	0	0	56,899	58,606	79,228	81,605	84,053	86,574	89,172	91,847
Maintenance Labor Cost ($/year)	0	0	0	0	0	0	0	48,515	49,970	51,470	53,014	54,604	56,242	57,929	59,667
Operational Labor Cost ($/year)	0	0	0	0	0	0	0	97,030	99,941	102,939	106,027	109,208	112,484	115,859	119,335
Odor Control	0	0	0	0	0	0	0	28,902	29,769	30,662	31,582	32,529	33,505	34,511	35,546
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	0	0	0	0	0	0	0	551,521	568,066	603,972	622,091	640,754	659,976	679,776	700,169
R&R Costs:															
Total Annual Repair and Replacement C	0	0	0	0	0	0	0	12,731	13,113	13,506	13,911	14,329	14,759	15,201	15,657
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	0	0	0	0	0	0	0	12,731	13,113	13,506	13,911	14,329	14,759	15,201	15,657
Net escalated benefit/(cost)	0	0	0	0	0	0	(15,265,319)	(564,252)	(581,179)	(617,478)	(636,003)	(655,083)	(674,735)	(694,977)	(715,827)
Life cycle cost analysis															
PVs in 2016	0	0	0	0	0	0	(13,555,166)	(491,215)	(496,031)	(516,678)	(521,744)	(526,859)	(532,024)	(537,240)	(542,507)
NPV as of 2016	(26,827,336)														

Year	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Expressed in 2016 dollars, unescalated															
Capital Outlays															
Total															
Total capital outlays	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benefits:															
							0								
Other															
Other															
Total benefits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:															
Energy Cost ($/year)	$20,745	$20,745	$20,745	$20,745	$20,745	$20,745	$20,745	$20,745	$20,745	$20,745	$20,745	$20,745	$20,745	$20,745	$20,745
Total Polymer Cost ($/year)	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586
Annual Water Cost ($/year)	$60,722	$60,722	$60,722	$60,722	$60,722	$60,722	$60,722	$60,722	$60,722	$60,722	$60,722	$60,722	$60,722	$60,722	$60,722
Maintenance Labor Cost ($/year)	$39,447	$39,447	$39,447	$39,447	$39,447	$39,447	$39,447	$39,447	$39,447	$39,447	$39,447	$39,447	$39,447	$39,447	$39,447
Operational Labor Cost ($/year)	$78,894	$78,894	$78,894	$78,894	$78,894	$78,894	$78,894	$78,894	$78,894	$78,894	$78,894	$78,894	$78,894	$78,894	$78,894
Odor Control	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500
Other															
Other															
Total running costs	462,894	462,894	462,894	462,894	462,894	462,894	462,894	462,894	462,894	462,894	462,894	462,894	462,894	462,894	462,894
R&R Costs:															
Total Annual Repair and Replacement Cost	10,351	10,351	10,351	10,351	10,351	10,351	50,394	10,351	10,351	10,351	10,351	10,351	10,351	202,663	10,351
Other															
Other															
Other															
Other															
Total refurbishments	10,351	10,351	10,351	10,351	10,351	10,351	50,394	10,351	10,351	10,351	10,351	10,351	10,351	202,663	10,351
Net Benefit/(cost)	(473,246)	(473,246)	(473,246)	(473,246)	(473,246)	(473,246)	(513,288)	(473,246)	(473,246)	(473,246)	(473,246)	(473,246)	(473,246)	(665,558)	(473,246)
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benefits:															
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:															
Energy Cost ($/year)	32,320	33,290	34,289	35,317	36,377	37,468	38,592	39,750	40,943	42,171	43,436	44,739	46,081	47,464	48,888
Total Polymer Cost ($/year)	373,267	384,465	395,999	407,879	420,116	432,719	445,701	459,072	472,844	487,029	501,640	516,689	532,190	548,155	564,600
Annual Water Cost ($/year)	94,602	97,440	100,363	103,374	106,476	109,670	112,960	116,349	119,839	123,434	127,137	130,952	134,880	138,927	143,094
Maintenance Labor Cost ($/year)	61,457	63,301	65,200	67,156	69,171	71,246	73,383	75,585	77,852	80,188	82,594	85,071	87,623	90,252	92,960
Operational Labor Cost ($/year)	122,915	126,602	130,400	134,312	138,342	142,492	146,767	151,170	155,705	160,376	165,187	170,143	175,247	180,504	185,920
Odor Control	36,612	37,711	38,842	40,007	41,207	42,444	43,717	45,028	46,379	47,771	49,204	50,680	52,200	53,766	55,379
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	721,174	742,809	765,094	788,046	811,688	836,038	861,120	886,953	913,562	940,969	969,198	998,274	1,028,222	1,059,069	1,090,841
R&R Costs:															
Total Annual Repair and Replacement C	16,127	16,611	17,109	17,623	18,151	18,696	93,747	19,834	20,429	21,042	21,674	22,324	22,994	463,679	24,394
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	16,127	16,611	17,109	17,623	18,151	18,696	93,747	19,834	20,429	21,042	21,674	22,324	22,994	463,679	24,394
Net escalated benefit/(cost)	(737,301)	(759,420)	(782,203)	(805,669)	(829,839)	(854,734)	(954,866)	(906,788)	(933,991)	(962,011)	(990,871)	(1,020,597)	(1,051,215)	(1,522,748)	(1,115,234)
Life cycle cost analysis															
PVs in 2016	(547,826)	(553,197)	(558,620)	(564,097)	(569,627)	(575,212)	(629,998)	(586,546)	(592,296)	(598,103)	(603,967)	(609,888)	(615,867)	(874,627)	(628,002)

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2016	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

Inland Empire Utilities Agency
RP-5 (2016-22, 22-30, 30-45)
Life Cycle Alternative Cost Analysis ($)
-

Gravity Belt Thickener Separate

Year

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Expressed in 2016 dollars, unescalated															
Capital Outlays															
Total Capital							14,523,769								
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**14,523,769**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Other															
Other															
Other															
Total benefits	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Annual Running Costs:															
Energy Cost ($/year)								$19,525	$19,525	$19,525	$19,525	$19,525	$19,525	$19,525	$19,525
Total Polymer Cost ($/year)								$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586
Annual Water Cost ($/year)								$98,311	$98,311	$98,311	$98,311	$98,311	$98,311	$98,311	$98,311
Maintenance Labor Cost ($/year)								52,596	52,596	52,596	52,596	52,596	52,596	52,596	52,596
Operational Labor Cost ($/year)								105,192	105,192	105,192	105,192	105,192	105,192	105,192	105,192
Odor Control								23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500
Total running costs			**0**	**0**	**0**	**0**	**0**	**538,711**	**538,711**	**538,711**	**538,711**	**538,711**	**538,711**	**538,711**	**538,711**
R&R Costs:															
Total Annual Repair and Replacement Cost					0	0	0	31,756	31,756	39,137	31,756	39,137	31,756	39,137	31,756
Other															
Other															
Other															
Other															
Total refurbishments		**0**	**0**	**0**	**0**	**0**	**0**	**31,756**	**31,756**	**39,137**	**31,756**	**39,137**	**31,756**	**39,137**	**31,756**
Net Benefit/(cost)	**0**	**0**	**0**	**0**	**0**	**0**	**(14,523,769)**	**(570,466)**	**(570,466)**	**(577,847)**	**(570,466)**	**(577,847)**	**(570,466)**	**(577,847)**	**(570,466)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Total Capital	0	0	0	0	0	0	17,342,140	0	0	0	0	0	0	0	0
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**17,342,140**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Annual Running Costs:															
Energy Cost ($/year)	0	0	0	0	0	0	0	24,013	24,734	25,476	26,240	27,027	27,838	28,673	29,533
Total Polymer Cost ($/year)	0	0	0	0	0	0	0	294,661	303,500	312,605	321,984	331,643	341,592	351,840	362,395
Annual Water Cost ($/year)	0	0	0	0	0	0	0	120,910	124,538	128,274	132,122	136,086	140,168	144,373	148,704
Maintenance Labor Cost ($/year)	0	0	0	0	0	0	0	64,687	66,627	68,626	70,685	72,805	74,990	77,239	79,556
Operational Labor Cost ($/year)	0	0	0	0	0	0	0	129,373	133,255	137,252	141,370	145,611	149,979	154,479	159,113
Odor Control	0	0	0	0	0	0	0	28,902	29,769	30,662	31,582	32,529	33,505	34,511	35,546
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**662,546**	**682,422**	**702,895**	**723,982**	**745,701**	**768,072**	**791,115**	**814,848**
R&R Costs:															
Total Annual Repair and Replacement Cost	0	0	0	0	0	0	0	39,055	40,227	51,064	42,677	54,174	45,276	57,473	48,033
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**39,055**	**40,227**	**51,064**	**42,677**	**54,174**	**45,276**	**57,473**	**48,033**
Net escalated benefit/(cost)	**0**	**0**	**0**	**0**	**0**	**0**	**(17,342,140)**	**(701,602)**	**(722,650)**	**(753,960)**	**(766,659)**	**(799,876)**	**(813,348)**	**(848,588)**	**(862,881)**
Life cycle cost analysis															
PVs in 2016	0	0	0	0	0	0	(15,399,324)	(610,786)	(616,774)	(630,880)	(628,927)	(643,310)	(641,320)	(655,986)	(653,956)
NPV as of 2016	**(32,591,733)**														

	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Expressed in 2016 dollars, unescalated															
Capital Outlays															
Total Capital															
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Other															
Other															
Other															
Total benefits	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Annual Running Costs:															
Energy Cost ($/year)	$19,525	$19,525	$19,525	$19,525	$19,525	$19,525	$19,525	$19,525	$19,525	$29,287	$29,287	$29,287	$29,287	$29,287	$29,287
Total Polymer Cost ($/year)	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586	$239,586
Annual Water Cost ($/year)	$98,311	$98,311	$98,311	$98,311	$98,311	$98,311	$98,311	$98,311	$98,311	$138,792	$138,792	$138,792	$138,792	$138,792	$138,792
Maintenance Labor Cost ($/year)	52,596	52,596	52,596	52,596	52,596	52,596	52,596	52,596	52,596	78,894	78,894	78,894	78,894	78,894	78,894
Operational Labor Cost ($/year)	105,192	105,192	105,192	105,192	105,192	105,192	105,192	105,192	105,192	157,789	157,789	157,789	157,789	157,789	157,789
Odor Control	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500
Total running costs	**538,711**	**538,711**	**538,711**	**538,711**	**538,711**	**538,711**	**538,711**	**538,711**	**538,711**	**667,848**	**667,848**	**667,848**	**667,848**	**667,848**	**667,848**
R&R Costs:															
Total Annual Repair and Replacement Cost	39,137	31,756	45,837	31,756	39,137	31,756	39,137	31,756	39,137	31,756	39,137	31,756	39,137	344,268	39,137
Other															
Other															
Other															
Other															
Total refurbishments	**39,137**	**31,756**	**45,837**	**31,756**	**39,137**	**31,756**	**39,137**	**31,756**	**39,137**	**31,756**	**39,137**	**31,756**	**39,137**	**344,268**	**39,137**
Net Benefit/(cost)	**(577,847)**	**(570,466)**	**(584,548)**	**(570,466)**	**(577,847)**	**(570,466)**	**(577,847)**	**(570,466)**	**(577,847)**	**(699,604)**	**(706,985)**	**(699,604)**	**(706,985)**	**(1,012,117)**	**(706,985)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Total Capital	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Annual Running Costs:															
Energy Cost ($/year)	30,419	31,332	32,272	33,240	34,237	35,264	36,322	37,412	38,534	59,535	61,321	63,161	65,056	67,008	69,018
Total Polymer Cost ($/year)	373,267	384,465	395,999	407,879	420,116	432,719	445,701	459,072	472,844	487,029	501,640	516,689	532,190	548,155	564,600
Annual Water Cost ($/year)	153,165	157,760	162,493	167,368	172,389	177,561	182,888	188,374	194,025	282,136	290,600	299,318	308,297	317,546	327,073
Maintenance Labor Cost ($/year)	81,943	84,401	86,933	89,541	92,228	94,995	97,844	100,780	103,803	160,376	165,187	170,143	175,247	180,504	185,920
Operational Labor Cost ($/year)	163,886	168,803	173,867	179,083	184,455	189,989	195,689	201,559	207,606	320,752	330,374	340,285	350,494	361,009	371,839
Odor Control	36,612	37,711	38,842	40,007	41,207	42,444	43,717	45,028	46,379	47,771	49,204	50,680	52,200	53,766	55,379
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**839,294**	**864,472**	**890,407**	**917,119**	**944,632**	**972,971**	**1,002,160**	**1,032,225**	**1,063,192**	**1,357,598**	**1,398,326**	**1,440,276**	**1,483,484**	**1,527,989**	**1,573,828**
R&R Costs:															
Total Annual Repair and Replacement Cost	60,974	50,959	75,762	54,062	68,626	57,354	72,806	60,847	77,240	64,553	81,943	68,484	86,934	787,661	92,228
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	**60,974**	**50,959**	**75,762**	**54,062**	**68,626**	**57,354**	**72,806**	**60,847**	**77,240**	**64,553**	**81,943**	**68,484**	**86,934**	**787,661**	**92,228**
Net escalated benefit/(cost)	**(900,267)**	**(915,431)**	**(966,169)**	**(971,181)**	**(1,013,259)**	**(1,030,326)**	**(1,074,966)**	**(1,093,072)**	**(1,140,431)**	**(1,422,151)**	**(1,480,270)**	**(1,508,760)**	**(1,570,418)**	**(2,315,650)**	**(1,666,056)**
Life cycle cost analysis															
PVs in 2016	(668,912)	(666,842)	(690,002)	(679,981)	(695,532)	(693,380)	(709,237)	(707,042)	(723,211)	(884,182)	(902,270)	(901,604)	(920,048)	(1,330,050)	(938,177)

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2016	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

Inland Empire Utilities Agency
RP-5 (2016-22, 22-30, 30-45)
Life Cycle Alternative Cost Analysis ($)
-

DAFT Co-thickening

Year

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Expressed in 2016 dollars, unescalated																														
Capital Outlays																														
Total Capital							19,047,354																							
Total capital outlays	0	0	0	0	0	0	19,047,354	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benefits:																														
																					0									
Other																														
Other																														
Total benefits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:																														
Energy Cost ($/year)								$235,623	$235,623	$471,246	$471,246	$471,246	$471,246	$471,246	$471,246	$471,246	$471,246	$471,246	$471,246	$471,246	$471,246	$471,246	$471,246	$471,246	$471,246	$471,246	$471,246	$471,246	$471,246	$471,246
Total Polymer Cost ($/year)								$291,158	$295,313	$299,469	$309,948	$320,427	$330,906	$341,385	$351,865	$358,188	$364,512	$370,835	$377,159	$383,483	$390,439	$397,395	$404,351	$411,307	$418,263	$423,502	$428,742	$433,981	$439,221	$444,461
Annual Water Cost ($/year)								$23,132	$23,132	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915
Maintenance Labor Cost ($/year)								$90,789	$90,789	$181,578	$181,578	$181,578	$181,578	$181,578	$181,578	$181,578	$181,578	$181,578	$181,578	$181,578	$181,578	$181,578	$181,578	$181,578	$181,578	$181,578	$181,578	$181,578	$181,578	$181,578
Operational Labor Cost ($/year)								$30,263	$30,263	$60,526	$60,526	$60,526	$60,526	$60,526	$60,526	$60,526	$60,526	$60,526	$60,526	$60,526	$60,526	$60,526	$60,526	$60,526	$60,526	$60,526	$60,526	$60,526	$60,526	$60,526
Odor Control								$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500	$23,500
Other																														
Other																														
Total running costs	0	0	0	0	0	0	0	694,464	698,620	1,065,233	1,075,712	1,086,191	1,096,671	1,107,150	1,117,629	1,123,953	1,130,276	1,136,600	1,142,923	1,149,247	1,156,203	1,163,159	1,170,115	1,177,071	1,184,027	1,189,267	1,194,506	1,199,746	1,204,985	1,210,225
R&R Costs:																														
Total Annual Repair and Replacement Cost								3,853	3,853	7,706	7,706	12,706	7,706	12,706	7,706	7,706	12,706	7,706	12,706	7,706	7,706	19,206	7,706	19,206	7,706	7,706	12,706	7,706	619,642	7,706
Other																														
Other																														
Other																														
Other																														
Total refurbishments		0	0	0	0	0	0	3,853	3,853	7,706	7,706	12,706	7,706	12,706	7,706	7,706	12,706	7,706	12,706	7,706	7,706	19,206	7,706	19,206	7,706	7,706	12,706	7,706	619,642	7,706
Net Benefit/(cost)	0	0	0	0	0	0	(19,047,354)	(698,318)	(702,473)	(1,072,940)	(1,083,419)	(1,098,898)	(1,104,377)	(1,119,856)	(1,125,335)	(1,131,659)	(1,142,983)	(1,144,306)	(1,155,630)	(1,156,953)	(1,163,909)	(1,182,365)	(1,177,821)	(1,196,277)	(1,191,733)	(1,196,973)	(1,207,213)	(1,207,452)	(1,824,627)	(1,217,931)
Expressed in escalated dollars with sensitivity adjustments																														
Capital Outlays																														
Total Capital	0	0	0	0	0	0	22,743,537	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	0	0	0	0	0	0	22,743,537	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benefits:																														
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:																														
Energy Cost ($/year)	0	0	0	0	0	0	0	289,786	298,480	614,869	633,315	652,314	671,884	692,040	712,801	734,185	756,211	778,897	802,264	826,332	851,122	876,656	902,955	930,044	957,945	986,684	1,016,284	1,046,773	1,078,176	1,110,521
Total Polymer Cost ($/year)	0	0	0	0	0	0	0	358,087	374,094	390,739	416,544	443,546	471,793	501,336	532,227	558,046	584,934	612,934	642,088	672,439	705,176	739,271	774,778	811,749	850,242	886,720	924,621	963,998	1,004,906	1,047,400
Annual Water Cost ($/year)	0	0	0	0	0	0	0	28,449	29,303	37,728	38,859	40,025	41,226	42,463	43,737	45,049	46,400	47,792	49,226	50,703	52,224	53,790	55,404	57,066	58,778	60,542	62,358	64,229	66,155	68,140
Maintenance Labor Cost ($/year)	0	0	0	0	0	0	0	111,659	115,009	236,918	244,025	251,346	258,886	266,653	274,653	282,892	291,379	300,120	309,124	318,398	327,950	337,788	347,922	358,359	369,110	380,184	391,589	403,337	415,437	427,900
Operational Labor Cost ($/year)	0	0	0	0	0	0	0	37,220	38,336	78,973	81,342	83,782	86,295	88,884	91,551	94,297	97,126	100,040	103,041	106,133	109,317	112,596	115,974	119,453	123,037	126,728	130,530	134,446	138,479	142,633
Odor Control	0	0	0	0	0	0	0	28,902	29,769	30,662	31,582	32,529	33,505	34,511	35,546	36,612	37,711	38,842	40,007	41,207	42,444	43,717	45,028	46,379	47,771	49,204	50,680	52,200	53,766	55,379
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	0	0	0	0	0	0	0	854,104	884,991	1,389,888	1,445,667	1,503,543	1,563,590	1,625,887	1,690,514	1,751,081	1,813,761	1,878,626	1,945,751	2,015,212	2,088,231	2,163,818	2,242,061	2,323,051	2,406,883	2,490,060	2,576,062	2,664,982	2,756,919	2,851,974
R&R Costs:																														
Total Annual Repair and Replacement Cost	0	0	0	0	0	0	0	4,739	4,881	10,055	10,357	17,589	10,987	18,660	11,657	12,006	20,390	12,738	21,632	13,513	13,919	35,730	14,766	37,905	15,666	16,135	27,403	17,118	1,417,696	18,161
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	0	0	0	0	0	0	0	4,739	4,881	10,055	10,357	17,589	10,987	18,660	11,657	12,006	20,390	12,738	21,632	13,513	13,919	35,730	14,766	37,905	15,666	16,135	27,403	17,118	1,417,696	18,161
Net escalated benefit/(cost)	0	0	0	0	0	0	(22,743,537)	(858,843)	(889,872)	(1,399,943)	(1,456,024)	(1,521,132)	(1,574,578)	(1,644,547)	(1,702,171)	(1,763,088)	(1,834,151)	(1,891,364)	(1,967,382)	(2,028,725)	(2,102,150)	(2,199,548)	(2,256,828)	(2,360,957)	(2,422,549)	(2,506,196)	(2,603,464)	(2,682,100)	(4,174,616)	(2,870,135)
Life cycle cost analysis																														
PVs in 2016	0	0	0	0	0	0	(20,195,610)	(747,674)	(759,497)	(1,171,409)	(1,194,447)	(1,223,390)	(1,241,544)	(1,271,288)	(1,290,033)	(1,310,000)	(1,336,080)	(1,350,741)	(1,377,481)	(1,392,579)	(1,414,687)	(1,451,209)	(1,459,804)	(1,497,215)	(1,506,151)	(1,527,604)	(1,555,776)	(1,571,341)	(2,397,793)	(1,616,208)
NPV as of 2016	(51,859,560)																													

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2016	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

Inland Empire Utilities Agency
RP-5 (2016-22, 22-30, 30-45)
Life Cycle Alternative Cost Analysis ($)
-

Centrifuges Co-thickening

Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Expressed in 2016 dollars, unescalated															
Capital Outlays															
Total Capital							21,469,777								
Total capital outlays	0	0	0	0	0	0	21,469,777	0	0	0	0	0	0	0	0
Benefits:															
Other															
Other															
Other															
Total benefits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:															
Energy Cost ($/year)								$252,197	$252,197	$252,197	$252,197	$252,197	$252,197	$252,197	$252,197
Total Polymer Cost ($/year)								238,220	241,620	245,020	253,594	262,168	270,741	279,315	287,889
Annual Water Cost ($/year)								$29,493	$29,493	$29,493	$29,493	$29,493	$29,493	$29,493	$29,493
Maintenance Labor Cost ($/year)								35,064	35,064	35,064	35,064	35,064	35,064	35,064	35,064
Operational Labor Cost ($/year)								70,128	70,128	70,128	70,128	70,128	70,128	70,128	70,128
Odor Control								23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500
Total running costs		0	0	0	0	0	0	648,603	652,003	655,403	663,977	672,551	681,125	689,698	698,272
R&R Costs:															
Total Annual Repair and Replacement Cost					0	0	0	14,234	16,783	40,682	16,783	25,921	31,544	25,921	16,783
Total refurbishments		0	0	0	0	0	0	14,234	16,783	40,682	16,783	25,921	31,544	25,921	16,783
Net Benefit/(cost)	0	0	0	0	0	0	(21,469,777)	(662,838)	(668,786)	(696,086)	(680,759)	(698,471)	(712,669)	(715,619)	(715,055)
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Total Capital	0	0	0	0	0	0	25,636,037	0	0	0	0	0	0	0	0
Total capital outlays	0	0	0	0	0	0	25,636,037	0	0	0	0	0	0	0	0
Benefits:															
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:															
Energy Cost ($/year)	0	0	0	0	0	0	0	310,171	319,476	329,060	338,932	349,100	359,573	370,360	381,471
Total Polymer Cost ($/year)	0	0	0	0	0	0	0	292,981	306,077	319,695	340,809	362,901	386,013	410,184	435,458
Annual Water Cost ($/year)	0	0	0	0	0	0	0	36,273	37,361	38,482	39,637	40,826	42,050	43,312	44,611
Maintenance Labor Cost ($/year)	0	0	0	0	0	0	0	43,124	44,418	45,751	47,123	48,537	49,993	51,493	53,038
Operational Labor Cost ($/year)	0	0	0	0	0	0	0	86,249	88,836	91,501	94,246	97,074	99,986	102,986	106,075
Odor Control	0	0	0	0	0	0	0	28,902	29,769	30,662	31,582	32,529	33,505	34,511	35,546
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	0	0	0	0	0	0	0	797,700	825,938	855,152	892,329	930,967	971,121	1,012,845	1,056,199
R&R Costs:															
Total Annual Repair and Replacement Cost	0	0	0	0	0	0	0	17,507	21,260	53,081	22,554	35,880	44,975	38,065	25,385
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	0	0	0	0	0	0	0	17,507	21,260	53,081	22,554	35,880	44,975	38,065	25,385
Net escalated benefit/(cost)	0	0	0	0	0	0	(25,636,037)	(815,207)	(847,198)	(908,234)	(914,884)	(966,848)	(1,016,096)	(1,050,911)	(1,081,585)
Life cycle cost analysis															
PVs in 2016	0	0	0	0	0	0	(22,764,067)	(709,686)	(723,075)	(759,969)	(750,523)	(777,600)	(801,184)	(812,388)	(819,706)
NPV as of 2016	(46,737,780)														

Year	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Expressed in 2016 dollars, unescalated															
Capital Outlays															
Total Capital															
Total capital outlays	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benefits:															
Other															
Other															
Other															
Total benefits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:															
Energy Cost ($/year)	$252,197	$252,197	$252,197	$252,197	$378,296	$378,296	$378,296	$378,296	$378,296	$378,296	$378,296	$378,296	$378,296	$378,296	$378,296
Total Polymer Cost ($/year)	293,063	298,237	303,411	308,585	313,759	319,450	325,141	330,832	336,524	342,215	346,502	350,789	355,076	359,363	363,650
Annual Water Cost ($/year)	$29,493	$29,493	$29,493	$29,493	$35,565	$35,565	$35,565	$35,565	$35,565	$35,565	$35,565	$35,565	$35,565	$35,565	$35,565
Maintenance Labor Cost ($/year)	35,064	35,064	35,064	35,064	52,596	52,596	52,596	52,596	52,596	52,596	52,596	52,596	52,596	52,596	52,596
Operational Labor Cost ($/year)	70,128	70,128	70,128	70,128	105,192	105,192	105,192	105,192	105,192	105,192	105,192	105,192	105,192	105,192	105,192
Odor Control	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500
Total running costs	703,446	708,620	713,794	718,968	908,909	914,600	920,291	925,982	931,674	937,365	941,652	945,939	950,226	954,513	958,800
R&R Costs:															
Total Annual Repair and Replacement Cost	40,682	16,783	40,682	14,234	16,783	156,645	16,783	25,921	31,544	25,921	16,783	40,682	16,783	667,994	14,234
Total refurbishments	40,682	16,783	40,682	14,234	16,783	156,645	16,783	25,921	31,544	25,921	16,783	40,682	16,783	667,994	14,234
Net Benefit/(cost)	(744,129)	(725,403)	(754,476)	(733,202)	(925,691)	(1,071,245)	(937,074)	(951,903)	(963,218)	(963,286)	(958,435)	(986,621)	(967,008)	(1,622,507)	(973,034)
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Total Capital	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benefits:															
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:															
Energy Cost ($/year)	392,915	404,703	416,844	429,349	663,345	683,245	703,742	724,854	746,600	768,998	792,068	815,830	840,305	865,514	891,480
Total Polymer Cost ($/year)	456,583	478,583	501,492	525,345	550,178	576,962	604,858	633,909	664,158	695,652	725,498	756,508	788,726	822,196	856,964
Annual Water Cost ($/year)	45,950	47,328	48,748	50,210	62,364	64,235	66,162	68,147	70,192	72,297	74,466	76,700	79,001	81,371	83,812
Maintenance Labor Cost ($/year)	54,629	56,268	57,956	59,694	92,228	94,995	97,844	100,780	103,803	106,917	110,125	113,428	116,831	120,336	123,946
Operational Labor Cost ($/year)	109,258	112,535	115,911	119,389	184,455	189,989	195,689	201,559	207,606	213,834	220,249	226,857	233,663	240,673	247,893
Odor Control	36,612	37,711	38,842	40,007	41,207	42,444	43,717	45,028	46,379	47,771	49,204	50,680	52,200	53,766	55,379
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	1,095,946	1,137,127	1,179,793	1,223,995	1,593,777	1,651,869	1,712,013	1,774,278	1,838,739	1,905,470	1,971,610	2,040,003	2,110,726	2,183,856	2,259,474
R&R Costs:															
Total Annual Repair and Replacement Cost	63,382	26,931	67,242	24,233	29,428	282,918	31,221	49,667	62,256	52,691	35,139	87,736	37,279	1,528,323	33,544
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	63,382	26,931	67,242	24,233	29,428	282,918	31,221	49,667	62,256	52,691	35,139	87,736	37,279	1,528,323	33,544
Net escalated benefit/(cost)	(1,159,328)	(1,164,058)	(1,247,035)	(1,248,228)	(1,623,205)	(1,934,788)	(1,743,233)	(1,823,945)	(1,900,994)	(1,958,162)	(2,006,749)	(2,127,739)	(2,148,005)	(3,712,179)	(2,293,019)
Life cycle cost analysis															
PVs in 2016	(861,398)	(847,953)	(890,585)	(873,958)	(1,114,218)	(1,302,057)	(1,150,143)	(1,179,799)	(1,205,527)	(1,217,431)	(1,223,176)	(1,271,493)	(1,258,435)	(2,132,181)	(1,291,227)

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2016	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

Inland Empire Utilities Agency
RP-5 (2016-22, 22-30, 30-45)
Life Cycle Alternative Cost Analysis ($)
-

Rotary Drum Thickener Co-thickening

Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Expressed in 2016 dollars, unescalated															
Capital Outlays															
Total Capital							11,212,164								
Total capital outlays	0	0	0	0	0	0	11,212,164	0	0	0	0	0	0	0	0
Benefits:															
Other															
Other															
Other															
Total benefits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:															
Energy Cost ($/year)								$13,830	$13,830	$13,830	$13,830	$13,830	$13,830	$13,830	$13,830
Total Polymer Cost ($/year)								238,220	241,620	245,020	253,594	262,168	270,741	279,315	287,889
Annual Water Cost ($/year)								$52,047	$52,047	$52,047	$52,047	$52,047	$52,047	$52,047	$52,047
Maintenance Labor Cost ($/year)								26,298	26,298	26,298	26,298	26,298	26,298	26,298	26,298
Operational Labor Cost ($/year)								52,596	52,596	52,596	52,596	52,596	52,596	52,596	52,596
Odor Control								23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500
Total running costs		0	0	0	0	0	0	406,491	409,891	413,291	421,865	430,439	439,013	447,587	456,161
R&R Costs:															
Total Annual Repair and Replacement Cost								6,862	6,862	6,862	6,862	6,862	6,862	6,862	6,862
Other															
Other															
Other															
Other															
Total refurbishments		0	0	0	0	0	0	6,862	6,862	6,862	6,862	6,862	6,862	6,862	6,862
Net Benefit/(cost)	0	0	0	0	0	0	(11,212,164)	(413,354)	(416,754)	(420,154)	(428,728)	(437,301)	(445,875)	(454,449)	(463,023)
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Total Capital	0	0	0	0	0	0	13,387,910	0	0	0	0	0	0	0	0
Total capital outlays	0	0	0	0	0	0	13,387,910	0	0	0	0	0	0	0	0
Benefits:															
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:															
Energy Cost ($/year)	0	0	0	0	0	0	0	17,009	17,520	18,045	18,587	19,144	19,719	20,310	20,919
Total Polymer Cost ($/year)	0	0	0	0	0	0	0	292,981	306,077	319,695	340,809	362,901	386,013	410,184	435,458
Annual Water Cost ($/year)	0	0	0	0	0	0	0	64,011	65,932	67,910	69,947	72,045	74,207	76,433	78,726
Maintenance Labor Cost ($/year)	0	0	0	0	0	0	0	32,343	33,314	34,313	35,342	36,403	37,495	38,620	39,778
Operational Labor Cost ($/year)	0	0	0	0	0	0	0	64,687	66,627	68,626	70,685	72,805	74,990	77,239	79,556
Odor Control	0	0	0	0	0	0	0	28,902	29,769	30,662	31,582	32,529	33,505	34,511	35,546
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	0	0	0	0	0	0	0	499,933	519,238	539,252	566,952	595,828	625,928	657,296	689,984
R&R Costs:															
Total Annual Repair and Replacement Cost	0	0	0	0	0	0	0	8,440	8,693	8,954	9,222	9,499	9,784	10,078	10,380
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	0	0	0	0	0	0	0	8,440	8,693	8,954	9,222	9,499	9,784	10,078	10,380
Net escalated benefit/(cost)	0	0	0	0	0	0	(13,387,910)	(508,373)	(527,931)	(548,205)	(576,174)	(605,327)	(635,712)	(667,374)	(700,364)
Life cycle cost analysis															
PVs in 2016	0	0	0	0	0	0	(11,888,081)	(442,569)	(450,584)	(458,714)	(472,663)	(486,843)	(501,254)	(515,902)	(530,788)
NPV as of 2016	(26,382,504)														

Year	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Expressed in 2016 dollars, unescalated															
Capital Outlays															
Total Capital															
Total capital outlays	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benefits:															
Other															
Other															
Other															
Total benefits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:															
Energy Cost ($/year)	$13,830	$13,830	$13,830	$13,830	$20,745	$20,745	$20,745	$20,745	$20,745	$20,745	$20,745	$20,745	$20,745	$20,745	$20,745
Total Polymer Cost ($/year)	293,063	298,237	303,411	308,585	313,759	319,450	325,141	330,832	336,524	342,215	346,502	350,789	355,076	359,363	363,650
Annual Water Cost ($/year)	$52,047	$52,047	$52,047	$52,047	$69,396	$69,396	$69,396	$69,396	$69,396	$69,396	$69,396	$69,396	$69,396	$69,396	$69,396
Maintenance Labor Cost ($/year)	26,298	26,298	26,298	26,298	39,447	39,447	39,447	39,447	39,447	39,447	39,447	39,447	39,447	39,447	39,447
Operational Labor Cost ($/year)	52,596	52,596	52,596	52,596	78,894	78,894	78,894	78,894	78,894	78,894	78,894	78,894	78,894	78,894	78,894
Odor Control	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500
Total running costs	461,335	466,508	471,682	476,856	545,741	551,433	557,124	562,815	568,506	574,198	578,485	582,771	587,058	591,345	595,632
R&R Costs:															
Total Annual Repair and Replacement Cost	6,862	6,862	6,862	6,862	10,293	10,293	39,564	10,293	10,293	10,293	10,293	10,293	10,293	202,605	10,293
Other															
Other															
Other															
Other															
Total refurbishments	6,862	6,862	6,862	6,862	10,293	10,293	39,564	10,293	10,293	10,293	10,293	10,293	10,293	202,605	10,293
Net Benefit/(cost)	(468,197)	(473,371)	(478,545)	(483,719)	(556,035)	(561,726)	(596,688)	(573,109)	(578,800)	(584,491)	(588,778)	(593,065)	(597,352)	(793,951)	(605,926)
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Total Capital	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benefits:															
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:															
Energy Cost ($/year)	21,547	22,193	22,859	23,545	36,377	37,468	38,592	39,750	40,943	42,171	43,436	44,739	46,081	47,464	48,888
Total Polymer Cost ($/year)	456,583	478,583	501,492	525,345	550,178	576,962	604,858	633,909	664,158	695,652	725,498	756,508	788,726	822,196	856,964
Annual Water Cost ($/year)	81,088	83,520	86,026	88,607	121,686	125,337	129,097	132,970	136,959	141,068	145,300	149,659	154,149	158,773	163,536
Maintenance Labor Cost ($/year)	40,972	42,201	43,467	44,771	69,171	71,246	73,383	75,585	77,852	80,188	82,594	85,071	87,623	90,252	92,960
Operational Labor Cost ($/year)	81,943	84,401	86,933	89,541	138,342	142,492	146,767	151,170	155,705	160,376	165,187	170,143	175,247	180,504	185,920
Odor Control	36,612	37,711	38,842	40,007	41,207	42,444	43,717	45,028	46,379	47,771	49,204	50,680	52,200	53,766	55,379
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	718,744	748,609	779,619	811,816	956,961	995,949	1,036,414	1,078,412	1,121,996	1,167,226	1,211,218	1,256,800	1,304,026	1,352,955	1,403,646
R&R Costs:															
Total Annual Repair and Replacement Cost	10,691	11,012	11,342	11,683	18,050	18,591	73,601	19,723	20,315	20,925	21,552	22,199	22,865	463,546	24,257
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	10,691	11,012	11,342	11,683	18,050	18,591	73,601	19,723	20,315	20,925	21,552	22,199	22,865	463,546	24,257
Net escalated benefit/(cost)	(729,435)	(759,621)	(790,961)	(823,498)	(975,010)	(1,014,540)	(1,110,015)	(1,098,135)	(1,142,312)	(1,188,150)	(1,232,770)	(1,278,999)	(1,326,891)	(1,816,502)	(1,427,904)
Life cycle cost analysis															
PVs in 2016	(541,981)	(553,343)	(564,875)	(576,580)	(669,277)	(682,756)	(732,361)	(710,317)	(724,404)	(738,698)	(751,412)	(764,303)	(777,375)	(1,043,352)	(804,070)

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2016	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

Inland Empire Utilities Agency
RP-5 (2016-22, 22-30, 30-45)
Life Cycle Alternative Cost Analysis ($)
-

Gravity Belt Thickener Co-thickening

Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Expressed in 2016 dollars, unescalated															
Capital Outlays															
Total Capital							11,850,933								
Total capital outlays	0	0	0	0	0	0	11,850,933	0	0	0	0	0	0	0	0
Benefits:															
Other															
Other															
Other															
Total benefits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:															
Energy Cost ($/year)								$19,525	$19,525	$19,525	$19,525	$19,525	$19,525	$19,525	$19,525
Total Polymer Cost ($/year)								$238,220	$241,620	$245,020	$253,594	$262,168	$270,741	$279,315	$287,889
Annual Water Cost ($/year)								$98,311	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915
Maintenance Labor Cost ($/year)								52,596	52,596	52,596	52,596	52,596	52,596	52,596	52,596
Operational Labor Cost ($/year)								105,192	105,192	105,192	105,192	105,192	105,192	105,192	105,192
Odor Control								23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500
Total running costs			0	0	0	0	0	537,345	471,348	474,748	483,322	491,896	500,470	509,044	517,618
R&R Costs:															
Total Annual Repair and Replacement Cost					0	0	0	23,112	11,556	25,572	23,112	28,032	23,112	28,032	23,112
Other															
Other															
Other															
Other															
Total refurbishments		0	0	0	0	0	0	23,112	11,556	25,572	23,112	28,032	23,112	28,032	23,112
Net Benefit/(cost)	0	0	0	0	0	0	(11,850,933)	(560,456)	(482,904)	(500,321)	(506,434)	(519,929)	(523,582)	(537,076)	(540,729)
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Total Capital	0	0	0	0	0	0	14,150,633	0	0	0	0	0	0	0	0
Total capital outlays	0	0	0	0	0	0	14,150,633	0	0	0	0	0	0	0	0
Benefits:															
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:															
Energy Cost ($/year)	0	0	0	0	0	0	0	24,013	24,734	25,476	26,240	27,027	27,838	28,673	29,533
Total Polymer Cost ($/year)	0	0	0	0	0	0	0	292,981	306,077	319,695	340,809	362,901	386,013	410,184	435,458
Annual Water Cost ($/year)	0	0	0	0	0	0	0	120,910	36,629	37,728	38,859	40,025	41,226	42,463	43,737
Maintenance Labor Cost ($/year)	0	0	0	0	0	0	0	64,687	66,627	68,626	70,685	72,805	74,990	77,239	79,556
Operational Labor Cost ($/year)	0	0	0	0	0	0	0	129,373	133,255	137,252	141,370	145,611	149,979	154,479	159,113
Odor Control	0	0	0	0	0	0	0	28,902	29,769	30,662	31,582	32,529	33,505	34,511	35,546
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	0	0	0	0	0	0	0	660,866	597,090	619,439	649,545	680,899	713,551	747,548	782,943
R&R Costs:															
Total Annual Repair and Replacement Cost	0	0	0	0	0	0	0	28,425	14,639	33,366	31,060	38,803	32,952	41,166	34,959
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	0	0	0	0	0	0	0	28,425	14,639	33,366	31,060	38,803	32,952	41,166	34,959
Net escalated benefit/(cost)	0	0	0	0	0	0	(14,150,633)	(689,291)	(611,729)	(652,805)	(680,605)	(719,703)	(746,502)	(788,715)	(817,902)
Life cycle cost analysis															
PVs in 2016	0	0	0	0	0	0	(12,565,357)	(600,069)	(522,105)	(546,238)	(558,333)	(578,830)	(588,612)	(609,702)	(619,867)
NPV as of 2016	(28,506,613)														

Year	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Expressed in 2016 dollars, unescalated															
Capital Outlays															
Total Capital															
Total capital outlays	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benefits:															
Other															
Other															
Other															
Total benefits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:															
Energy Cost ($/year)	$19,525	$19,525	$19,525	$19,525	$19,525	$19,525	$19,525	$19,525	$19,525	$19,525	$19,525	$19,525	$19,525	$19,525	$19,525
Total Polymer Cost ($/year)	$293,063	$298,237	$303,411	$308,585	$313,759	$319,450	$325,141	$330,832	$336,524	$342,215	$346,502	$350,789	$355,076	$359,363	$363,650
Annual Water Cost ($/year)	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915	$28,915
Maintenance Labor Cost ($/year)	52,596	52,596	52,596	52,596	52,596	52,596	52,596	52,596	52,596	52,596	52,596	52,596	52,596	52,596	52,596
Operational Labor Cost ($/year)	105,192	105,192	105,192	105,192	105,192	105,192	105,192	105,192	105,192	105,192	105,192	105,192	105,192	105,192	105,192
Odor Control	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500	23,500
Total running costs	522,792	527,965	533,139	538,313	543,487	549,178	554,870	560,561	566,252	571,943	576,230	580,517	584,804	589,091	593,378
R&R Costs:															
Total Annual Repair and Replacement Cost	28,032	23,112	30,266	23,112	30,266	23,112	28,032	23,112	28,032	23,112	28,032	23,112	28,032	331,157	28,032
Other															
Other															
Other															
Other															
Total refurbishments	28,032	23,112	30,266	23,112	30,266	23,112	28,032	23,112	28,032	23,112	28,032	23,112	28,032	331,157	28,032
Net Benefit/(cost)	(550,824)	(551,077)	(563,405)	(561,425)	(573,753)	(572,290)	(582,902)	(583,673)	(594,284)	(595,055)	(604,263)	(603,629)	(612,837)	(920,248)	(621,410)
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Total Capital	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benefits:															
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Running Costs:															
Energy Cost ($/year)	30,419	31,332	32,272	33,240	34,237	35,264	36,322	37,412	38,534	39,690	40,881	42,107	43,371	44,672	46,012
Total Polymer Cost ($/year)	456,583	478,583	501,492	525,345	550,178	576,962	604,858	633,909	664,158	695,652	725,498	756,508	788,726	822,196	856,964
Annual Water Cost ($/year)	45,049	46,400	47,792	49,226	50,703	52,224	53,790	55,404	57,066	58,778	60,542	62,358	64,229	66,155	68,140
Maintenance Labor Cost ($/year)	81,943	84,401	86,933	89,541	92,228	94,995	97,844	100,780	103,803	106,917	110,125	113,428	116,831	120,336	123,946
Operational Labor Cost ($/year)	163,886	168,803	173,867	179,083	184,455	189,989	195,689	201,559	207,606	213,834	220,249	226,857	233,663	240,673	247,893
Odor Control	36,612	37,711	38,842	40,007	41,207	42,444	43,717	45,028	46,379	47,771	49,204	50,680	52,200	53,766	55,379
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	814,492	847,230	881,198	916,442	953,008	991,877	1,032,221	1,074,093	1,117,548	1,162,643	1,206,498	1,251,938	1,299,019	1,347,798	1,398,334
R&R Costs:															
Total Annual Repair and Replacement Cost	43,674	37,088	50,025	39,346	53,072	41,742	52,148	44,284	55,324	46,981	58,694	49,843	62,268	757,664	66,060
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	43,674	37,088	50,025	39,346	53,072	41,742	52,148	44,284	55,324	46,981	58,694	49,843	62,268	757,664	66,060
Net escalated benefit/(cost)	(858,166)	(884,317)	(931,223)	(955,788)	(1,006,079)	(1,033,620)	(1,084,369)	(1,118,377)	(1,172,872)	(1,209,625)	(1,265,192)	(1,301,781)	(1,361,287)	(2,105,462)	(1,464,394)
Life cycle cost analysis															
PVs in 2016	(637,630)	(644,177)	(665,045)	(669,204)	(690,604)	(695,596)	(715,441)	(723,410)	(743,784)	(752,050)	(771,174)	(777,917)	(797,526)	(1,209,324)	(824,618)

Inland Empire Utilities Agency
149055 - IEUA - RP5 - Digestion
Alternatives Net Present Value Analysis

			Sensitivity Adjustments (%)			Results ($000s)		
Agency:	Inland Empire Utilities Agency	Risk Premium	Benefits	Capital Costs	Running Costs	Capital Cost	20-year NPV	Difference from Highest NPV
Project/Problem:	149055 - IEUA - RP5 - Digestion							
Alternative 1	THP					$116,538,345	($274,254,479)	($139,240,036)
Alternative 2	MAD					$70,332,830	($152,476,515)	($17,462,071)
Alternative 3	2 Phase					$61,077,295	($135,014,444)	
Alternative 4								
Alternative 5								
Alternative 6								
Alternative 7								
Alternative 8								
Alternative 9								
Alternative 10								
Alternative 11								
Alternative 12								
Alternative 13								
Alternative 14								
Alternative 15								
Alternative 16								

Year of analysis:	2016
Escalation rate:	3.00%
Discount rate:	2.00%

From Summary Sheet:

Risk adjustments (+/- percent):

Year of analysis	2016	**Benefits**	
Escalation rate	3.00%	**Capital costs**	
Discount rate	2.00%	**Running costs**	

Inland Empire Utilities Agency
149055 - IEUA - RP5 - Digestion
Life Cycle Alternative Cost Analysis ($000s)
Alternative 1 - THP

	Year																													
	2016	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**
Expressed in 2016 dollars, unescalated																														
Capital Outlays																														
THP								116,538,345																						
Other																														
Other																														
Other																														
Other																														
Other																														
Total capital outlays								**116,538,345**																						
Benefits:																														
THP Dewatering Benefit								$437,653	$444,006	$450,358	$466,066	$481,774	$497,482	$513,190	$528,898	$538,517	$548,136	$557,756	$567,375	$576,995	$587,409	$597,824	$608,238	$618,653	$629,068	$636,922	$644,776	$652,630	$660,483	$668,337
Gas Benefit								188,341	191,195	193,498	196,331	199,185	202,039	204,892	227,232	230,005	232,858	235,712	238,565	247,889	251,122	253,975	256,829	259,683	270,254	273,380	276,234	279,087	281,941	287,121
Total benefits								**625,994**	**635,201**	**643,856**	**662,398**	**680,959**	**699,521**	**718,082**	**756,130**	**768,522**	**780,995**	**793,468**	**805,941**	**824,883**	**838,531**	**851,799**	**865,067**	**878,336**	**899,321**	**910,302**	**921,009**	**931,717**	**942,424**	**955,458**
Annual Running Costs:																														
Electrical								$1,924,500	$1,924,500	$1,924,500	$1,924,500	$1,924,500	$1,924,500	$1,924,500	$2,055,900	$2,055,900	$2,055,900	$2,055,900	$2,055,900	$2,055,900	$2,055,900	$2,055,900	$2,055,900	$2,055,900	$2,055,900	$2,055,900	$2,055,900	$2,055,900	$2,055,900	$2,055,900
Polymer								$1,057,000	$1,072,400	$1,087,700	$1,125,600	$1,163,600	$1,201,500	$1,239,500	$1,277,400	$1,300,600	$1,323,800	$1,347,100	$1,370,300	$1,393,500	$1,418,600	$1,443,800	$1,468,900	$1,494,100	$1,519,200	$1,538,200	$1,557,200	$1,576,100	$1,595,100	$1,614,000
Labor								$1,202,200	$1,202,200	$1,402,600	$1,402,600	$1,402,600	$1,402,600	$1,402,600	$1,402,600	$1,402,600	$1,402,600	$1,402,600	$1,402,600	$1,402,600	$1,402,600	$1,402,600	$1,402,600	$1,402,600	$1,402,600	$1,402,600	$1,402,600	$1,402,600	$1,402,600	$1,402,600
Maintenance								$360,660	$360,660	$420,780	$420,780	$420,780	$420,780	$420,780	$420,780	$420,780	$420,780	$420,780	$420,780	$420,780	$420,780	$420,780	$420,780	$420,780	$420,780	$420,780	$420,780	$420,780	$420,780	$420,780
Other																														
Other																														
Total running costs								**4,544,360**	**4,559,760**	**4,835,580**	**4,873,480**	**4,911,480**	**4,949,380**	**4,987,380**	**5,156,680**	**5,179,880**	**5,203,080**	**5,226,380**	**5,249,580**	**5,272,780**	**5,297,880**	**5,323,080**	**5,348,180**	**5,373,380**	**5,398,480**	**5,417,480**	**5,436,480**	**5,455,380**	**5,474,380**	**5,493,280**
R&R Costs:																														
Other								1,058,212	1,058,212	1,058,212	1,058,212	1,058,212	1,058,212	1,058,212	1,058,212	1,058,212	1,058,212	1,058,212	1,058,212	1,058,212	1,058,212	1,058,212	1,058,212	1,058,212	1,058,212	1,058,212	1,058,212	1,058,212	1,058,212	1,058,212
Other																														
Other																														
Other																														
Other																														
Total refurbishments								**1,058,212**	**1,058,212**	**1,058,212**	**1,058,212**	**1,058,212**	**1,058,212**	**1,058,212**	**1,058,212**	**1,058,212**	**1,058,212**	**1,058,212**	**1,058,212**	**1,058,212**	**1,058,212**	**1,058,212**	**1,058,212**	**1,058,212**	**1,058,212**	**1,058,212**	**1,058,212**	**1,058,212**	**1,058,212**	**1,058,212**
Net Benefit/(cost)								**(121,514,923)**	**(4,982,771)**	**(5,249,935)**	**(5,269,294)**	**(5,288,733)**	**(5,308,071)**	**(5,327,510)**	**(5,458,762)**	**(5,469,570)**	**(5,480,297)**	**(5,491,124)**	**(5,501,851)**	**(5,506,108)**	**(5,517,561)**	**(5,529,493)**	**(5,541,324)**	**(5,553,256)**	**(5,557,370)**	**(5,565,390)**	**(5,573,682)**	**(5,581,875)**	**(5,590,167)**	**(5,596,034)**
Expressed in escalated dollars with sensitivity adjustments																														
Capital Outlays																														
THP								143,327,465																						
Other																														
Other																														
Other																														
Other																														
Other																														
Total capital outlays								**143,327,465**																						
Benefits:																														
THP Dewatering Benefit								538,258	562,453	587,615	626,354	666,888	709,290	753,636	800,005	838,992	879,598	921,885	965,918	1,011,764	1,060,926	1,112,128	1,165,448	1,220,965	1,278,765	1,333,572	1,390,517	1,449,679	1,511,138	1,574,981
Gas Benefit								231,636	242,200	252,471	263,853	275,719	288,059	300,891	343,709	358,340	373,669	389,596	406,142	434,674	453,553	472,469	492,111	512,506	549,370	572,397	595,723	619,934	645,061	676,619
Total benefits								**769,894**	**804,653**	**840,087**	**890,207**	**942,607**	**997,349**	**1,054,528**	**1,143,714**	**1,197,332**	**1,253,267**	**1,311,481**	**1,372,060**	**1,446,438**	**1,514,480**	**1,584,597**	**1,657,558**	**1,733,471**	**1,828,135**	**1,905,970**	**1,986,241**	**2,069,612**	**2,156,199**	**2,251,600**
Annual Running Costs:																														
Electrical								2,366,892	2,437,899	2,511,036	2,586,367	2,663,958	2,743,877	2,826,193	3,109,733	3,203,025	3,299,116	3,398,089	3,500,032	3,605,033	3,713,184	3,824,580	3,939,317	4,057,497	4,179,221	4,304,598	4,433,736	4,566,748	4,703,751	4,844,863
Polymer								1,299,977	1,358,484	1,419,202	1,512,712	1,610,695	1,713,052	1,820,248	1,932,182	2,026,292	2,124,310	2,226,551	2,332,844	2,443,511	2,562,149	2,685,893	2,814,564	2,948,736	3,088,221	3,220,649	3,358,244	3,500,974	3,649,473	3,803,497
Labor								1,478,554	1,522,911	1,830,075	1,884,977	1,941,526	1,999,772	2,059,765	2,121,558	2,185,205	2,250,761	2,318,284	2,387,833	2,459,468	2,533,252	2,609,249	2,687,527	2,768,152	2,851,197	2,936,733	3,024,835	3,115,580	3,209,047	3,305,319
Maintenance								443,566	456,873	549,022	565,493	582,458	599,932	617,930	636,468	655,562	675,228	695,485	716,350	737,840	759,975	782,775	806,258	830,446	855,359	881,020	907,450	934,674	962,714	991,596
Other																														
Other																														
Total running costs								**5,588,990**	**5,776,168**	**6,309,335**	**6,549,550**	**6,798,637**	**7,056,632**	**7,324,136**	**7,799,941**	**8,070,084**	**8,349,416**	**8,638,410**	**8,937,059**	**9,245,852**	**9,568,561**	**9,902,497**	**10,247,666**	**10,604,830**	**10,973,998**	**11,343,000**	**11,724,265**	**12,117,976**	**12,524,986**	**12,945,274**
R&R Costs:																														
Other								1,301,467	1,340,511	1,380,726	1,422,148	1,464,813	1,508,757	1,554,020	1,600,640	1,648,659	1,698,119	1,749,063	1,801,535	1,855,581	1,911,248	1,968,586	2,027,643	2,088,472	2,151,127	2,215,660	2,282,130	2,350,594	2,421,112	2,493,745
Other																														
Other																														
Other																														
Other																														
Total refurbishments								**1,301,467**	**1,340,511**	**1,380,726**	**1,422,148**	**1,464,813**	**1,508,757**	**1,554,020**	**1,600,640**	**1,648,659**	**1,698,119**	**1,749,063**	**1,801,535**	**1,855,581**	**1,911,248**	**1,968,586**	**2,027,643**	**2,088,472**	**2,151,127**	**2,215,660**	**2,282,130**	**2,350,594**	**2,421,112**	**2,493,745**
Net escalated benefit/(cost)								**(149,448,028)**	**(6,312,026)**	**(6,849,975)**	**(7,081,491)**	**(7,320,843)**	**(7,568,040)**	**(7,823,627)**	**(8,256,867)**	**(8,521,412)**	**(8,794,268)**	**(9,075,991)**	**(9,366,533)**	**(9,654,994)**	**(9,965,329)**	**(10,286,485)**	**(10,617,751)**	**(10,959,831)**	**(11,296,990)**	**(11,652,691)**	**(12,020,155)**	**(12,398,957)**	**(12,789,898)**	**(13,187,420)**
Life cycle cost analysis																														
PVs in 2016								(130,103,502)	(5,387,253)	(5,731,753)	(5,809,289)	(5,887,883)	(5,967,348)	(6,047,919)	(6,257,673)	(6,331,535)	(6,406,148)	(6,481,733)	(6,558,066)	(6,627,485)	(6,706,381)	(6,786,774)	(6,867,976)	(6,950,242)	(7,023,581)	(7,102,675)	(7,182,996)	(7,264,078)	(7,346,192)	(7,425,998)
NPV as of 2016	(274,254,479)																													

Inland Empire Utilities Agency
149055 - IEUA - RP5 - Digestion
Life Cycle Alternative Cost Analysis ($000s)
Alternative 2 - MAD

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2016	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	2.00%	Running costs	

Expressed in 2016 dollars, unescalated

Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capital Outlays															
MAD								70,332,830							
Other															
Other															
Other															
Other															
Other															
Total capital outlays								**70,332,830**							
Benefits:															
Other															
Other															
Other															
Total benefits															
Annual Running Costs:															
Electrical								769,700	769,700	769,700	769,700	769,700	769,700	769,700	1,156,200
labor								801,500	801,500	801,500	801,500	801,500	801,500	801,500	1,001,900
maintenance								240,450	240,450	240,450	240,450	240,450	240,450	240,450	300,570
Total running costs								**1,811,650**	**1,811,650**	**1,811,650**	**1,811,650**	**1,811,650**	**1,811,650**	**1,811,650**	**2,458,670**
R&R Costs:															
Other								424,453	424,453	424,453	424,453	424,453	424,453	424,453	424,453
Other															
Other															
Other															
Other															
Total refurbishments								**424,453**	**424,453**	**424,453**	**424,453**	**424,453**	**424,453**	**424,453**	**424,453**
Net Benefit/(cost)								**(72,568,933)**	**(2,236,103)**	**(2,236,103)**	**(2,236,103)**	**(2,236,103)**	**(2,236,103)**	**(2,236,103)**	**(2,883,123)**

Year	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Capital Outlays															
MAD															
Other															
Other															
Other															
Other															
Other															
Total capital outlays															
Benefits:															
Other															
Other															
Other															
Total benefits															
Annual Running Costs:															
Electrical	1,156,200	1,156,200	1,156,200	1,156,200	1,156,200	1,156,200	1,156,200	1,156,200	1,156,200	1,276,600	1,276,600	1,276,600	1,276,600	1,276,600	1,276,600
labor	1,001,900	1,001,900	1,001,900	1,001,900	1,001,900	1,001,900	1,001,900	1,001,900	1,001,900	1,202,200	1,202,200	1,202,200	1,202,200	1,202,200	1,202,200
maintenance	300,570	300,570	300,570	300,570	300,570	300,570	300,570	300,570	300,570	360,660	360,660	360,660	360,660	360,660	360,660
Total running costs	**2,458,670**	**2,458,670**	**2,458,670**	**2,458,670**	**2,458,670**	**2,458,670**	**2,458,670**	**2,458,670**	**2,458,670**	**2,839,460**	**2,839,460**	**2,839,460**	**2,839,460**	**2,839,460**	**2,839,460**
R&R Costs:															
Other	424,453	424,453	424,453	424,453	424,453	424,453	424,453	424,453	424,453	424,453	424,453	424,453	424,453	424,453	424,453
Other															
Other															
Other															
Other															
Total refurbishments	**424,453**	**424,453**	**424,453**	**424,453**	**424,453**	**424,453**	**424,453**	**424,453**	**424,453**	**424,453**	**424,453**	**424,453**	**424,453**	**424,453**	**424,453**
Net Benefit/(cost)	**(2,883,123)**	**(2,883,123)**	**(2,883,123)**	**(2,883,123)**	**(2,883,123)**	**(2,883,123)**	**(2,883,123)**	**(2,883,123)**	**(2,883,123)**	**(3,263,913)**	**(3,263,913)**	**(3,263,913)**	**(3,263,913)**	**(3,263,913)**	**(3,263,913)**

Expressed in escalated dollars with sensitivity adjustments

Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capital Outlays															
MAD								86,500,510							
Other															
Other															
Other															
Other															
Other															
Total capital outlays								**86,500,510**							
Benefits:															
Other															
Other															
Other															
Total benefits															
Annual Running Costs:															
Electrical								946,634	975,033	1,004,284	1,034,412	1,065,445	1,097,408	1,130,330	1,748,856
labor								985,744	1,015,316	1,045,776	1,077,149	1,109,463	1,142,747	1,177,030	1,515,464
maintenance								295,723	304,595	313,733	323,145	332,839	342,824	353,109	454,639
Total running costs								**2,228,101**	**2,294,944**	**2,363,792**	**2,434,706**	**2,507,747**	**2,582,980**	**2,660,469**	**3,718,959**
R&R Costs:															
Other								522,023	537,684	553,815	570,429	587,542	605,168	623,323	642,023
Other															
Other															
Other															
Other															
Total refurbishments								**522,023**	**537,684**	**553,815**	**570,429**	**587,542**	**605,168**	**623,323**	**642,023**
Net escalated benefit/(cost)								**(89,250,634)**	**(2,832,628)**	**(2,917,607)**	**(3,005,135)**	**(3,095,289)**	**(3,188,148)**	**(3,283,792)**	**(4,360,982)**

Year	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Capital Outlays															
MAD															
Other															
Other															
Other															
Other															
Other															
Total capital outlays															
Benefits:															
Other															
Other															
Other															
Total benefits															
Annual Running Costs:															
Electrical	1,801,322	1,855,362	1,911,022	1,968,353	2,027,404	2,088,226	2,150,873	2,215,399	2,281,861	2,595,065	2,672,917	2,753,104	2,835,698	2,920,768	3,008,392
labor	1,560,928	1,607,755	1,655,988	1,705,668	1,756,838	1,809,543	1,863,829	1,919,744	1,977,336	2,443,825	2,517,140	2,592,654	2,670,434	2,750,547	2,833,063
maintenance	468,278	482,327	496,796	511,700	527,051	542,863	559,149	575,923	593,201	733,148	755,142	777,796	801,130	825,164	849,919
Total running costs	**3,830,528**	**3,945,444**	**4,063,807**	**4,185,721**	**4,311,293**	**4,440,632**	**4,573,850**	**4,711,066**	**4,852,398**	**5,772,038**	**5,945,199**	**6,123,555**	**6,307,261**	**6,496,479**	**6,691,373**
R&R Costs:															
Other	661,283	681,122	701,556	722,602	744,280	766,609	789,607	813,295	837,694	862,825	888,710	915,371	942,832	971,117	1,000,251
Other															
Other															
Other															
Other															
Total refurbishments	**661,283**	**681,122**	**701,556**	**722,602**	**744,280**	**766,609**	**789,607**	**813,295**	**837,694**	**862,825**	**888,710**	**915,371**	**942,832**	**971,117**	**1,000,251**
Net escalated benefit/(cost)	**(4,491,811)**	**(4,626,566)**	**(4,765,363)**	**(4,908,323)**	**(5,055,573)**	**(5,207,240)**	**(5,363,458)**	**(5,524,361)**	**(5,690,092)**	**(6,634,863)**	**(6,833,908)**	**(7,038,926)**	**(7,250,093)**	**(7,467,596)**	**(7,691,624)**

Life cycle cost analysis

Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
PVs in 2016								(77,698,048)	(2,417,621)	(2,441,323)	(2,465,257)	(2,489,427)	(2,513,833)	(2,538,478)	(3,305,079)
NPV as of 2016	**(152,476,515)**														

Year	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
PVs in 2016	(3,337,482)	(3,370,202)	(3,403,244)	(3,436,609)	(3,470,301)	(3,504,323)	(3,538,680)	(3,573,373)	(3,608,406)	(4,125,037)	(4,165,478)	(4,206,316)	(4,247,555)	(4,289,197)	(4,331,248)

From Summary Sheet:

Year of analysis	2016	**Benefits**	
Escalation rate	3.00%	**Capital costs**	
Discount rate	2.00%	**Running costs**	

Risk adjustments (+/- percent):

Inland Empire Utilities Agency
149055 - IEUA - RP5 - Digestion
Life Cycle Alternative Cost Analysis ($000s)
Alternative 3 - 2 Phase

	Year																													
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Expressed in 2016 dollars, unescalated																														
Capital Outlays																														
2 Phase								61,077,295																						
Other																														
Other																														
Other																														
Other																														
Other																														
Total capital outlays								**61,077,295**																						
Benefits:																														
Dewatering Benefit								69,627	70,637	71,648	74,147	76,646	79,145	81,644	84,143	85,673	87,204	88,734	90,264	91,795	93,451	95,108	96,765	98,422	100,079	101,328	102,578	103,827	105,077	106,326
Gas benefit								188,341	191,195	193,498	196,331	199,185	202,039	204,892	227,232	230,005	232,858	235,712	238,565	247,889	251,122	253,975	256,829	259,683	270,254	273,380	276,234	279,087	281,941	287,121
Other																														
Total benefits								**257,968**	**261,832**	**265,146**	**270,478**	**275,831**	**281,184**	**286,536**	**311,375**	**315,678**	**320,062**	**324,446**	**328,830**	**339,683**	**344,573**	**349,084**	**353,594**	**358,105**	**370,333**	**374,708**	**378,812**	**382,915**	**387,018**	**393,447**
Annual Running Costs:																														
Electrical								652,800	652,800	652,800	652,800	652,800	652,800	652,800	1,152,300	1,152,300	1,152,300	1,152,300	1,152,300	1,152,300	1,152,300	1,152,300	1,152,300	1,152,300	1,305,600	1,305,600	1,305,600	1,305,600	1,305,600	1,305,600
Labor								901,700	901,700	901,700	901,700	901,700	901,700	901,700	1,102,100	1,102,100	1,102,100	1,102,100	1,102,100	1,102,100	1,102,100	1,102,100	1,102,100	1,102,100	1,322,500	1,322,500	1,322,500	1,322,500	1,322,500	1,322,500
maintenance								270,510	270,510	270,510	270,510	270,510	270,510	270,510	330,630	330,630	330,630	330,630	330,630	330,630	330,630	330,630	330,630	330,630	396,750	396,750	396,750	396,750	396,750	396,750
Total running costs								**1,825,010**	**1,825,010**	**1,825,010**	**1,825,010**	**1,825,010**	**1,825,010**	**1,825,010**	**2,585,030**	**2,585,030**	**2,585,030**	**2,585,030**	**2,585,030**	**2,585,030**	**2,585,030**	**2,585,030**	**2,585,030**	**2,585,030**	**3,024,850**	**3,024,850**	**3,024,850**	**3,024,850**	**3,024,850**	**3,024,850**
R&R Costs:																														
Other								368,490	368,490	368,490	368,490	368,490	368,490	368,490	368,490	368,490	368,490	368,490	368,490	368,490	368,490	368,490	368,490	368,490	368,490	368,490	368,490	368,490	368,490	368,490
Other																														
Other																														
Other																														
Other																														
Total refurbishments								**368,490**	**368,490**	**368,490**	**368,490**	**368,490**	**368,490**	**368,490**	**368,490**	**368,490**	**368,490**	**368,490**	**368,490**	**368,490**	**368,490**	**368,490**	**368,490**	**368,490**	**368,490**	**368,490**	**368,490**	**368,490**	**368,490**	**368,490**
Net Benefit/(cost)								**(63,012,828)**	**(1,931,668)**	**(1,928,354)**	**(1,923,022)**	**(1,917,669)**	**(1,912,317)**	**(1,906,964)**	**(2,642,145)**	**(2,637,843)**	**(2,633,459)**	**(2,629,075)**	**(2,624,691)**	**(2,613,837)**	**(2,608,947)**	**(2,604,437)**	**(2,599,926)**	**(2,595,416)**	**(3,023,008)**	**(3,018,632)**	**(3,014,529)**	**(3,010,425)**	**(3,006,322)**	**(2,999,893)**
Expressed in escalated dollars with sensitivity adjustments																														
Capital Outlays																														
2 Phase								75,117,369																						
Other																														
Other																														
Other																														
Other																														
Other																														
Total capital outlays								**75,117,369**																						
Benefits:																														
Dewatering Benefit								85,632	89,481	93,484	99,647	106,096	112,842	119,897	127,274	133,476	139,936	146,664	153,669	160,962	168,784	176,930	185,412	194,244	203,440	212,159	221,219	230,631	240,408	250,565
Gas benefit								231,636	242,200	252,471	263,853	275,719	288,059	300,891	343,709	358,340	373,669	389,596	406,142	434,674	453,553	472,469	492,111	512,506	549,370	572,397	595,723	619,934	645,061	676,619
Other																														
Total benefits								**317,268**	**331,681**	**345,955**	**363,500**	**381,814**	**400,901**	**420,788**	**470,983**	**491,816**	**513,605**	**536,259**	**559,811**	**595,637**	**622,337**	**649,398**	**677,523**	**706,750**	**752,810**	**784,556**	**816,942**	**850,564**	**885,469**	**927,184**
Annual Running Costs:																														
Electrical								802,862	826,948	851,756	877,309	903,628	930,737	958,659	1,742,957	1,795,246	1,849,103	1,904,576	1,961,714	2,020,565	2,081,182	2,143,617	2,207,926	2,274,164	2,654,016	2,733,636	2,815,646	2,900,115	2,987,118	3,076,732
Labor								1,108,977	1,142,247	1,176,514	1,211,809	1,248,164	1,285,609	1,324,177	1,667,025	1,717,036	1,768,547	1,821,603	1,876,251	1,932,539	1,990,515	2,050,231	2,111,738	2,175,090	2,688,370	2,769,021	2,852,092	2,937,655	3,025,784	3,116,558
maintenance								332,693	342,674	352,954	363,543	374,449	385,683	397,253	500,108	515,111	530,564	546,481	562,875	579,762	597,155	615,069	633,521	652,527	806,511	830,706	855,628	881,296	907,735	934,967
Total running costs								**2,244,532**	**2,311,868**	**2,381,224**	**2,452,661**	**2,526,241**	**2,602,028**	**2,680,089**	**3,910,090**	**4,027,393**	**4,148,214**	**4,272,661**	**4,400,841**	**4,532,866**	**4,668,852**	**4,808,917**	**4,953,185**	**5,101,780**	**6,148,897**	**6,333,364**	**6,523,365**	**6,719,066**	**6,920,638**	**7,128,257**
R&R Costs:																														
Other								453,197	466,792	480,796	495,220	510,077	525,379	541,140	557,375	574,096	591,319	609,058	627,330	646,150	665,534	685,500	706,065	727,247	749,065	771,537	794,683	818,523	843,079	868,371
Other																														
Other																														
Other																														
Other																														
Total refurbishments								**453,197**	**466,792**	**480,796**	**495,220**	**510,077**	**525,379**	**541,140**	**557,375**	**574,096**	**591,319**	**609,058**	**627,330**	**646,150**	**665,534**	**685,500**	**706,065**	**727,247**	**749,065**	**771,537**	**794,683**	**818,523**	**843,079**	**868,371**
Net escalated benefit/(cost)								**(77,497,830)**	**(2,446,979)**	**(2,516,065)**	**(2,584,381)**	**(2,654,503)**	**(2,726,506)**	**(2,800,441)**	**(3,996,482)**	**(4,109,673)**	**(4,225,928)**	**(4,345,460)**	**(4,468,360)**	**(4,583,379)**	**(4,712,049)**	**(4,845,019)**	**(4,981,727)**	**(5,122,277)**	**(6,145,152)**	**(6,320,345)**	**(6,501,106)**	**(6,687,025)**	**(6,878,248)**	**(7,069,445)**
Life cycle cost analysis																														
PVs in 2016								(67,466,525)	(2,088,473)	(2,105,330)	(2,120,092)	(2,134,919)	(2,149,832)	(2,164,832)	(3,028,834)	(3,053,547)	(3,078,359)	(3,103,365)	(3,128,564)	(3,146,172)	(3,171,074)	(3,196,627)	(3,222,376)	(3,248,322)	(3,820,573)	(3,852,445)	(3,884,926)	(3,917,674)	(3,950,691)	(3,980,891)
NPV as of 2016	**(135,014,444)**																													

RP-5 Dewatering

Inland Empire UTILITIES AGENCY

Inland Empire Utilities Agency

Alternatives Net Present Value Analysis

			Sensitivity Adjustments (%)			Results	
Agency:	Inland Empire Utilities Agency						
Project/Problem:		Risk Premium	Benefits	Capital Costs	Running Costs	Capital Cost	NPV
Alternative 1	Centrifuge					$64,333,526	($174,857,985)
Alternative 2	Belt Filter Press					$71,962,967	($192,882,039)
Alternative 3	Screw Press					$57,498,791	($177,641,253)

Year of analysis:	2016
Escalation rate:	3.00%
Discount rate:	2.00%

Make entries in yellow cells only.

From Summary Sheet:

Year of analysis	2016
Escalation rate	3.00%
Discount rate	2.00%

Risk adjustments (+/- percent):

Benefits	
Capital costs	
Running costs	

Inland Empire Utilities Agency

Life Cycle Alternative Cost Analysis ($000s)
Alternative 1 - Centrifuge

Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Expressed in 2016 dollars, unescalated															
Capital Outlays															
Total Capital							48,250,145	16,083,382							
Other															
Other															
Other															
Other															
Other															
Total capital outlays							**48,250,145**	**16,083,382**							
Benefits:															
Other															
Other															
Other															
Total benefits															
Annual Running Costs:															
Dewatering Electrical								27,007	27,399	27,791	28,760	29,729	30,699	31,668	32,637
Polymer Usage								797,294	808,868	820,442	849,056	877,669	906,283	934,896	963,510
Labor								50,092	50,092	50,092	50,092	50,092	50,092	50,092	50,092
Hauling & Disposal								2,032,352	2,061,855	2,091,359	2,164,296	2,237,234	2,310,171	2,383,108	2,456,046
Odor Control Operating Costs								56,115	56,115	56,115	56,115	56,115	56,115	56,115	56,115
Other															
Other															
Other															
Total running costs								**2,962,859**	**3,004,329**	**3,045,798**	**3,148,318**	**3,250,838**	**3,353,359**	**3,455,879**	**3,558,399**
R&R Costs:															
Other								75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000
Other															
Other															
Other															
Other															
Total refurbishments								**75,000**	**75,000**	**75,000**	**75,000**	**75,000**	**75,000**	**75,000**	**75,000**
Net Benefit/(cost)							**(48,250,145)**	**(19,121,241)**	**(3,079,329)**	**(3,120,798)**	**(3,223,318)**	**(3,325,838)**	**(3,428,359)**	**(3,530,879)**	**(3,633,399)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Total Capital							57,613,196	19,780,531							
Other															
Other															
Other															
Other															
Other															
Total capital outlays							**57,613,196**	**19,780,531**							
Benefits:															
Other															
Other															
Other															
Total benefits															
Annual Running Costs:															
Dewatering Electrical								33,215	34,708	36,261	38,651	41,152	43,769	46,505	49,366
Polymer Usage								980,571	1,024,650	1,070,491	1,141,060	1,214,900	1,292,143	1,372,927	1,457,395
Labor								61,606	63,455	65,358	67,319	69,338	71,419	73,561	75,768
Hauling & Disposal								2,499,537	2,611,897	2,728,749	2,908,633	3,096,854	3,293,751	3,499,675	3,714,990
Odor Control Operating Costs								69,014	71,084	73,217	75,413	77,676	80,006	82,406	84,878
Other															
Other															
Other															
Total running costs								**3,643,943**	**3,805,794**	**3,974,076**	**4,231,077**	**4,499,921**	**4,781,087**	**5,075,074**	**5,382,397**
R&R Costs:															
Other								92,241	95,008	97,858	100,794	103,818	106,932	110,140	113,444
Other															
Other															
Other															
Other															
Total refurbishments								**92,241**	**95,008**	**97,858**	**100,794**	**103,818**	**106,932**	**110,140**	**113,444**
Net escalated benefit/(cost)							**(57,613,196)**	**(23,516,715)**	**(3,900,802)**	**(4,071,934)**	**(4,331,870)**	**(4,603,738)**	**(4,888,020)**	**(5,185,214)**	**(5,495,842)**
Life cycle cost analysis															
PVs in 2016							(51,158,869)	(20,472,715)	(3,329,297)	(3,407,212)	(3,553,642)	(3,702,617)	(3,854,170)	(4,008,339)	(4,165,161)
NPV as of 2016	**(174,857,985)**														

Year	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Expressed in 2016 dollars, unescalated															
Capital Outlays															
Total Capital															
Other															
Other															
Other															
Other															
Other															
Total capital outlays															
Benefits:															
Other															
Other															
Other															
Total benefits															
Annual Running Costs:															
Dewatering Electrical	33,230	33,824	34,417	35,011	35,604	36,247	36,889	37,532	38,174	38,817	39,302	39,786	40,271	40,755	41,240
Polymer Usage	981,028	998,546	1,016,065	1,033,583	1,051,101	1,070,072	1,089,043	1,108,014	1,126,985	1,145,956	1,160,263	1,174,569	1,188,876	1,203,183	1,217,489
Labor	50,092	50,092	50,092	50,092	50,092	50,092	50,092	50,092	50,092	50,092	50,092	50,092	50,092	50,092	50,092
Hauling & Disposal	2,500,701	2,545,357	2,590,012	2,634,667	2,679,323	2,727,681	2,776,039	2,824,397	2,872,755	2,921,113	2,957,581	2,994,050	3,030,519	3,066,987	3,103,456
Odor Control Operating Costs	56,115	56,115	56,115	56,115	56,115	56,115	56,115	56,115	56,115	56,115	56,115	56,115	56,115	56,115	56,115
Other															
Other															
Other															
Total running costs	**3,621,166**	**3,683,933**	**3,746,700**	**3,809,467**	**3,872,234**	**3,940,206**	**4,008,177**	**4,076,149**	**4,144,120**	**4,212,092**	**4,263,352**	**4,314,612**	**4,365,872**	**4,417,132**	**4,468,392**
R&R Costs:															
Other	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000
Other															
Other															
Other															
Other															
Total refurbishments	**75,000**	**75,000**	**75,000**	**75,000**	**75,000**	**75,000**	**75,000**	**75,000**	**75,000**	**75,000**	**75,000**	**75,000**	**75,000**	**75,000**	**75,000**
Net Benefit/(cost)	**(3,696,166)**	**(3,758,933)**	**(3,821,700)**	**(3,884,467)**	**(3,947,234)**	**(4,015,206)**	**(4,083,177)**	**(4,151,149)**	**(4,219,120)**	**(4,287,092)**	**(4,338,352)**	**(4,389,612)**	**(4,440,872)**	**(4,492,132)**	**(4,543,392)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Total Capital															
Other															
Other															
Other															
Other															
Other															
Total capital outlays															
Benefits:															
Other															
Other															
Other															
Total benefits															
Annual Running Costs:															
Dewatering Electrical	51,772	54,277	56,886	59,603	62,432	65,465	68,625	71,915	75,340	78,907	82,289	85,803	89,453	93,245	97,185
Polymer Usage	1,528,410	1,602,374	1,679,400	1,759,606	1,843,113	1,932,670	2,025,941	2,123,070	2,224,202	2,329,492	2,429,332	2,533,066	2,640,837	2,752,795	2,869,094
Labor	78,041	80,382	82,794	85,278	87,836	90,471	93,185	95,981	98,860	101,826	104,881	108,027	111,268	114,606	118,044
Hauling & Disposal	3,896,011	4,084,550	4,280,895	4,485,345	4,698,209	4,926,495	5,164,250	5,411,836	5,669,630	5,938,020	6,192,518	6,456,942	6,731,658	7,017,045	7,313,498
Odor Control Operating Costs	87,425	90,048	92,749	95,531	98,397	101,349	104,390	107,522	110,747	114,070	117,492	121,016	124,647	128,386	132,238
Other															
Other															
Other															
Total running costs	**5,641,659**	**5,911,631**	**6,192,725**	**6,485,363**	**6,789,987**	**7,116,450**	**7,456,390**	**7,810,322**	**8,178,780**	**8,562,315**	**8,926,512**	**9,304,854**	**9,697,863**	**10,106,078**	**10,530,058**
R&R Costs:															
Other	116,848	120,353	123,964	127,682	131,513	135,458	139,522	143,708	148,019	152,460	157,033	161,744	166,597	171,595	176,742
Other															
Other															
Other															
Other															
Total refurbishments	**116,848**	**120,353**	**123,964**	**127,682**	**131,513**	**135,458**	**139,522**	**143,708**	**148,019**	**152,460**	**157,033**	**161,744**	**166,597**	**171,595**	**176,742**
Net escalated benefit/(cost)	**(5,758,506)**	**(6,031,984)**	**(6,316,688)**	**(6,613,046)**	**(6,921,500)**	**(7,251,908)**	**(7,595,913)**	**(7,954,030)**	**(8,326,799)**	**(8,714,774)**	**(9,083,545)**	**(9,466,598)**	**(9,864,460)**	**(10,277,673)**	**(10,706,800)**
Life cycle cost analysis															
PVs in 2016	(4,278,655)	(4,393,974)	(4,511,142)	(4,630,186)	(4,751,130)	(4,880,327)	(5,011,599)	(5,144,977)	(5,280,489)	(5,418,163)	(5,536,701)	(5,657,043)	(5,779,212)	(5,903,234)	(6,029,131)
NPV as of 2016															

From Summary Sheet:

Year of analysis	**2016**	**Benefits**	
Escalation rate	**3.00%**	**Capital costs**	
Discount rate	**2.00%**	**Running costs**	

Risk adjustments (+/- percent):

Inland Empire Utilities Agency

Life Cycle Alternative Cost Analysis ($000s)
Alternative 2 - Belt Filter Press

	Year																													
	2016	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**
Expressed in 2016 dollars, unescalated																														
Capital Outlays																														
Total Capital							53,972,225	17,990,742																						
Other																														
Other																														
Other																														
Other																														
Other																														
Other																														
Total capital outlays							**53,972,225**	**17,990,742**																						
Benefits:																														
Other																														
Other																														
Other																														
Total benefits																														
Annual Running Costs:																														
Dewatering Electrical								15,511	15,511	15,511	15,511	19,388	19,388	19,388	19,388	19,388	19,388	19,388	19,388	19,388	19,388	19,388	23,266	23,266	23,266	23,266	23,266	23,266	23,266	23,266
Polymer Usage								341,697	346,658	351,618	363,881	376,144	388,407	400,670	412,933	420,441	427,948	435,456	442,964	450,472	458,602	466,733	474,863	482,994	491,124	497,255	503,387	509,518	515,650	521,781
Labor								100,183	100,183	100,183	100,183	100,183	100,183	100,183	100,183	100,183	100,183	100,183	100,183	100,183	100,183	100,183	100,183	100,183	100,183	100,183	100,183	100,183	100,183	100,183
Hauling & Disposal								2,709,803	2,749,141	2,788,478	2,885,728	2,982,978	3,080,228	3,177,478	3,274,728	3,334,268	3,393,809	3,453,349	3,512,890	3,572,430	3,636,908	3,701,385	3,765,862	3,830,339	3,894,817	3,943,442	3,992,067	4,040,692	4,089,317	4,137,941
Odor Control Operating Costs								92,667	92,667	92,667	92,667	92,667	92,667	92,667	92,667	92,667	92,667	92,667	92,667	92,667	92,667	92,667	92,667	92,667	92,667	92,667	92,667	92,667	92,667	92,667
Other																														
Other																														
Other																														
Total running costs								**3,259,861**	**3,304,159**	**3,348,457**	**3,457,970**	**3,571,360**	**3,680,873**	**3,790,386**	**3,899,899**	**3,966,947**	**4,033,995**	**4,101,044**	**4,168,092**	**4,235,141**	**4,307,748**	**4,380,356**	**4,456,841**	**4,529,449**	**4,602,056**	**4,656,813**	**4,711,569**	**4,766,326**	**4,821,082**	**4,875,838**
R&R Costs:																														
Other								77,028	77,028	77,028	77,028	77,028	77,028	77,028	77,028	77,028	77,028	77,028	77,028	77,028	77,028	77,028	77,028	77,028	77,028	77,028	77,028	77,028	77,028	77,028
Other																														
Other																														
Other																														
Other																														
Total refurbishments								**77,028**	**77,028**	**77,028**	**77,028**	**77,028**	**77,028**	**77,028**	**77,028**	**77,028**	**77,028**	**77,028**	**77,028**	**77,028**	**77,028**	**77,028**	**77,028**	**77,028**	**77,028**	**77,028**	**77,028**	**77,028**	**77,028**	**77,028**
Net Benefit/(cost)							**(53,972,225)**	**(21,327,631)**	**(3,381,187)**	**(3,425,485)**	**(3,534,998)**	**(3,648,389)**	**(3,757,901)**	**(3,867,414)**	**(3,976,927)**	**(4,043,975)**	**(4,111,024)**	**(4,178,072)**	**(4,245,121)**	**(4,312,169)**	**(4,384,777)**	**(4,457,384)**	**(4,533,869)**	**(4,606,477)**	**(4,679,085)**	**(4,733,841)**	**(4,788,598)**	**(4,843,354)**	**(4,898,110)**	**(4,952,867)**
Expressed in escalated dollars with sensitivity adjustments																														
Capital Outlays																														
Total Capital							64,445,659	22,126,343																						
Other																														
Other																														
Other																														
Other																														
Other																														
Other																														
Total capital outlays							**64,445,659**	**22,126,343**																						
Benefits:																														
Other																														
Other																														
Other																														
Total benefits																														
Annual Running Costs:																														
Dewatering Electrical								19,076	19,648	20,238	20,845	26,838	27,643	28,472	29,326	30,206	31,112	32,046	33,007	33,997	35,017	36,068	44,580	45,917	47,295	48,714	50,175	51,680	53,231	54,827
Polymer Usage								420,245	439,136	458,782	489,026	520,671	553,775	588,397	624,598	655,033	686,732	719,743	754,117	789,905	828,287	868,260	909,887	953,230	998,354	1,041,142	1,085,600	1,131,787	1,179,769	1,229,612
Labor								123,213	126,909	130,716	134,638	138,677	142,837	147,122	151,536	156,082	160,765	165,588	170,555	175,672	180,942	186,370	191,961	197,720	203,652	209,761	216,054	222,536	229,212	236,088
Hauling & Disposal								3,332,716	3,482,529	3,638,332	3,878,177	4,129,139	4,391,669	4,666,234	4,953,320	5,194,682	5,446,067	5,707,860	5,980,460	6,264,278	6,568,660	6,885,666	7,215,781	7,559,506	7,917,360	8,256,691	8,609,256	8,975,544	9,356,060	9,751,330
Odor Control Operating Costs								113,968	117,387	120,909	124,536	128,272	132,121	136,084	140,167	144,372	148,703	153,164	157,759	162,492	167,366	172,387	177,559	182,886	188,372	194,023	199,844	205,839	212,015	218,375
Other																														
Other																														
Other																														
Total running costs								**4,009,218**	**4,185,610**	**4,368,977**	**4,647,222**	**4,943,598**	**5,248,045**	**5,566,309**	**5,898,947**	**6,180,374**	**6,473,378**	**6,778,401**	**7,095,898**	**7,426,345**	**7,780,272**	**8,148,752**	**8,539,768**	**8,939,259**	**9,355,033**	**9,750,332**	**10,160,929**	**10,587,387**	**11,030,287**	**11,490,233**
R&R Costs:																														
Other								94,735	97,577	100,505	103,520	106,625	109,824	113,119	116,512	120,008	123,608	127,316	131,136	135,070	139,122	143,296	147,594	152,022	156,583	161,280	166,119	171,102	176,235	181,522
Other																														
Other																														
Other																														
Other																														
Total refurbishments								**94,735**	**97,577**	**100,505**	**103,520**	**106,625**	**109,824**	**113,119**	**116,512**	**120,008**	**123,608**	**127,316**	**131,136**	**135,070**	**139,122**	**143,296**	**147,594**	**152,022**	**156,583**	**161,280**	**166,119**	**171,102**	**176,235**	**181,522**
Net escalated benefit/(cost)							**(64,445,659)**	**(26,230,296)**	**(4,283,187)**	**(4,469,481)**	**(4,750,742)**	**(5,050,223)**	**(5,357,869)**	**(5,679,428)**	**(6,015,459)**	**(6,300,382)**	**(6,596,986)**	**(6,905,717)**	**(7,227,034)**	**(7,561,414)**	**(7,919,394)**	**(8,292,048)**	**(8,687,363)**	**(9,091,281)**	**(9,511,616)**	**(9,911,612)**	**(10,327,048)**	**(10,758,489)**	**(11,206,522)**	**(11,671,755)**
Life cycle cost analysis																														
PVs in 2016							(57,225,901)	(22,835,051)	(3,655,659)	(3,739,862)	(3,897,263)	(4,061,708)	(4,224,643)	(4,390,383)	(4,558,966)	(4,681,277)	(4,805,547)	(4,931,804)	(5,060,075)	(5,190,387)	(5,329,525)	(5,470,892)	(5,619,325)	(5,765,290)	(5,913,576)	(6,041,434)	(6,171,230)	(6,302,990)	(6,436,741)	(6,572,509)
NPV as of 2016	**(192,882,039)**																													

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2016	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	2.00%	Running costs	

Inland Empire Utilities Agency

Life Cycle Alternative Cost Analysis ($000s)
Alternative 3 - Screw Press

Year

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Expressed in 2016 dollars, unescalated																														
Capital Outlays																														
Total Capital							43,124,093	14,374,698																						
Other																														
Other																														
Other																														
Other																														
Other																														
Total capital outlays							43,124,093	14,374,698																						
Benefits:																														
Other																														
Other																														
Other																														
Total benefits																														
Annual Running Costs:																														
Dewatering Electrical								17,449	17,449	17,449	17,449	17,449	17,449	17,449	17,449	17,449	17,449	17,449	17,449	17,449	17,449	17,449	17,449	17,449	17,449	17,449	17,449	17,449	17,449	17,449
Polymer Usage								569,496	577,763	586,030	606,468	626,907	647,345	667,783	688,221	700,734	713,247	725,761	738,274	750,787	764,337	777,888	791,439	804,989	818,540	828,759	838,978	849,197	859,416	869,635
Labor								150,275	150,275	150,275	150,275	150,275	150,275	150,275	150,275	150,275	150,275	150,275	150,275	150,275	150,275	150,275	150,275	150,275	150,275	150,275	150,275	150,275	150,275	150,275
Hauling & Disposal								2,438,823	2,474,227	2,509,630	2,597,155	2,684,680	2,772,205	2,859,730	2,947,255	3,000,842	3,054,428	3,108,014	3,161,601	3,215,187	3,273,217	3,331,246	3,389,276	3,447,305	3,505,335	3,549,097	3,592,860	3,636,622	3,680,385	3,724,147
Odor Control Operating Costs								56,115	56,115	56,115	56,115	56,115	56,115	56,115	56,115	56,115	56,115	56,115	56,115	56,115	56,115	56,115	56,115	56,115	56,115	56,115	56,115	56,115	56,115	56,115
Other																														
Other																														
Other																														
Total running costs								3,232,157	3,275,828	3,319,500	3,427,463	3,535,426	3,643,389	3,751,352	3,859,315	3,925,415	3,991,514	4,057,614	4,123,713	4,189,813	4,261,393	4,332,973	4,404,553	4,476,134	4,547,714	4,601,695	4,655,677	4,709,658	4,763,640	4,817,622
R&R Costs:																														
Other								126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950
Other																														
Other																														
Other																														
Other																														
Total refurbishments								126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950	126,950
Net Benefit/(cost)							(43,124,093)	(17,733,805)	(3,402,778)	(3,446,450)	(3,554,413)	(3,662,376)	(3,770,339)	(3,878,302)	(3,986,265)	(4,052,365)	(4,118,464)	(4,184,564)	(4,250,663)	(4,316,763)	(4,388,343)	(4,459,923)	(4,531,503)	(4,603,084)	(4,674,664)	(4,728,645)	(4,782,627)	(4,836,608)	(4,890,590)	(4,944,572)
Expressed in escalated dollars with sensitivity adjustments																														
Capital Outlays																														
Total Capital							51,492,422	17,679,065																						
Other																														
Other																														
Other																														
Other																														
Other																														
Total capital outlays							51,492,422	17,679,065																						
Benefits:																														
Other																														
Other																														
Other																														
Total benefits																														
Annual Running Costs:																														
Dewatering Electrical								21,461	22,104	22,767	23,451	24,154	24,879	25,625	26,394	27,186	28,001	28,841	29,706	30,598	31,516	32,461	33,435	34,438	35,471	36,535	37,631	38,760	39,923	41,121
Polymer Usage								700,408	731,893	764,637	815,043	867,785	922,959	980,662	1,040,996	1,091,721	1,144,553	1,199,572	1,256,861	1,316,509	1,380,478	1,447,101	1,516,478	1,588,716	1,663,923	1,735,237	1,809,333	1,886,312	1,966,282	2,049,353
Labor								184,819	190,364	196,075	201,957	208,015	214,256	220,684	227,304	234,123	241,147	248,381	255,833	263,508	271,413	279,555	287,942	296,580	305,478	314,642	324,081	333,804	343,818	354,132
Hauling & Disposal								2,999,444	3,134,276	3,274,498	3,490,360	3,716,225	3,952,502	4,199,610	4,457,988	4,675,213	4,901,460	5,137,074	5,382,414	5,637,851	5,911,794	6,197,100	6,494,203	6,803,556	7,125,624	7,431,022	7,748,330	8,077,989	8,420,454	8,776,197
Odor Control Operating Costs								69,014	71,084	73,217	75,413	77,676	80,006	82,406	84,878	87,425	90,048	92,749	95,531	98,397	101,349	104,390	107,522	110,747	114,070	117,492	121,016	124,647	128,386	132,238
Other																														
Other																														
Other																														
Total running costs								3,975,146	4,149,721	4,331,194	4,606,223	4,893,856	5,194,601	5,508,987	5,837,560	6,115,668	6,405,209	6,706,617	7,020,346	7,346,862	7,696,550	8,060,607	8,439,580	8,834,037	9,244,566	9,634,928	10,040,392	10,461,512	10,898,864	11,353,041
R&R Costs:																														
Other								156,132	160,816	165,641	170,610	175,728	181,000	186,430	192,023	197,784	203,717	209,829	216,124	222,608	229,286	236,164	243,249	250,547	258,063	265,805	273,779	281,993	290,452	299,166
Other																														
Other																														
Other																														
Other																														
Total refurbishments								156,132	160,816	165,641	170,610	175,728	181,000	186,430	192,023	197,784	203,717	209,829	216,124	222,608	229,286	236,164	243,249	250,547	258,063	265,805	273,779	281,993	290,452	299,166
Net escalated benefit/(cost)							(51,492,422)	(21,810,343)	(4,310,538)	(4,496,835)	(4,776,833)	(5,069,585)	(5,375,602)	(5,695,417)	(6,029,584)	(6,313,452)	(6,608,926)	(6,916,446)	(7,236,470)	(7,569,470)	(7,925,836)	(8,296,771)	(8,682,829)	(9,084,584)	(9,502,629)	(9,900,733)	(10,314,171)	(10,743,505)	(11,189,316)	(11,652,207)
Life cycle cost analysis																														
PVs in 2016							(45,723,798)	(18,987,216)	(3,679,003)	(3,762,750)	(3,918,667)	(4,077,280)	(4,238,625)	(4,402,743)	(4,569,671)	(4,690,988)	(4,814,245)	(4,939,467)	(5,066,682)	(5,195,917)	(5,333,860)	(5,474,009)	(5,616,393)	(5,761,042)	(5,907,989)	(6,034,802)	(6,163,535)	(6,294,212)	(6,426,858)	(6,561,501)
NPV as of 2016	(177,641,253)																													

RP-5 Odor Control

Inland Empire Utilities Agency

Inland Empire
UTILITIES AGENCY

Alternatives Net Present Value Analysis

			Sensitivity Adjustments (%)			Results ($000s)		
Agency:	Inland Empire Utilities Agency							
Project/Problem:		Risk Premium	Benefits	Capital Costs	Running Costs	Capital Cost	20-year NPV	Difference from highest NPV
Alternative 1	Biofilter					$4,792,919	($13,200,928)	($6,607,835)
Alternative 2	Bioscrubber+ Activated Carbon					$6,333,500	($11,956,550)	($5,363,458)
Alternative 3	Activated Carbon					$2,995,574	($6,593,093)	

Year of analysis:	2016
Escalation rate:	3.00%
Discount rate:	2.00%

Inland Empire Utilities Agency

Life Cycle Alternative Cost Analysis ($000s)
Alternative 1 - Biofilter

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2016	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	2.00%	Running costs	

Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Expressed in 2016 dollars, unescalated																														
Capital Outlays																														
Other	4,792,919																													
Other																														
Other																														
Other																														
Other																														
Other																														
Total capital outlays	**4,792,919**																													
Benefits:																														
Other																														
Other																														
Other																														
Total benefits																														
Annual Running Costs:																														
Other								177,475	185,461	193,807	202,528	211,642	221,166	231,118	241,519	252,387	263,744	275,613	288,015	300,976	314,520	328,673	343,464	358,920	375,071	391,949	409,587	428,018	447,279	467,407
Other																														
Other																														
Other																														
Other																														
Other																														
Other																														
Other																														
Total running costs								**177,475**	**185,461**	**193,807**	**202,528**	**211,642**	**221,166**	**231,118**	**241,519**	**252,387**	**263,744**	**275,613**	**288,015**	**300,976**	**314,520**	**328,673**	**343,464**	**358,920**	**375,071**	**391,949**	**409,587**	**428,018**	**447,279**	**467,407**
R&R Costs:																														
Other																														
Other																														
Other																														
Other																														
Other																														
Total refurbishments																														
Net Benefit/(cost)	**(4,792,919)**							**(177,475)**	**(185,461)**	**(193,807)**	**(202,528)**	**(211,642)**	**(221,166)**	**(231,118)**	**(241,519)**	**(252,387)**	**(263,744)**	**(275,613)**	**(288,015)**	**(300,976)**	**(314,520)**	**(328,673)**	**(343,464)**	**(358,920)**	**(375,071)**	**(391,949)**	**(409,587)**	**(428,018)**	**(447,279)**	**(467,407)**
Expressed in escalated dollars with sensitivity adjustments																														
Capital Outlays																														
Other	4,792,919																													
Other																														
Other																														
Other																														
Other																														
Other																														
Total capital outlays	**4,792,919**																													
Benefits:																														
Other																														
Other																														
Other																														
Total benefits																														
Annual Running Costs:																														
Other								218,272	234,937	252,874	272,181	292,962	315,330	339,405	365,319	393,211	423,232	455,546	490,327	527,763	568,058	611,429	658,112	708,359	762,442	820,654	883,311	950,752	1,023,342	1,101,474
Other																														
Other																														
Other																														
Other																														
Other																														
Other																														
Other																														
Total running costs								**218,272**	**234,937**	**252,874**	**272,181**	**292,962**	**315,330**	**339,405**	**365,319**	**393,211**	**423,232**	**455,546**	**490,327**	**527,763**	**568,058**	**611,429**	**658,112**	**708,359**	**762,442**	**820,654**	**883,311**	**950,752**	**1,023,342**	**1,101,474**
R&R Costs:																														
Other																														
Other																														
Other																														
Other																														
Other																														
Total refurbishments																														
Net escalated benefit/(cost)	**(4,792,919)**							**(218,272)**	**(234,937)**	**(252,874)**	**(272,181)**	**(292,962)**	**(315,330)**	**(339,405)**	**(365,319)**	**(393,211)**	**(423,232)**	**(455,546)**	**(490,327)**	**(527,763)**	**(568,058)**	**(611,429)**	**(658,112)**	**(708,359)**	**(762,442)**	**(820,654)**	**(883,311)**	**(950,752)**	**(1,023,342)**	**(1,101,474)**
Life cycle cost analysis																														
PVs in 2016	(4,792,919)							(190,018)	(200,516)	(211,594)	(223,283)	(235,618)	(248,635)	(262,371)	(276,866)	(292,161)	(308,302)	(325,334)	(343,307)	(362,273)	(382,287)	(403,406)	(425,693)	(449,210)	(474,027)	(500,214)	(527,849)	(557,010)	(587,782)	(620,254)
NPV as of 2016	(13,200,928)																													

From Summary Sheet:

Year of analysis	**2016**
Escalation rate	**3.00%**
Discount rate	**2.00%**

Risk adjustments (+/- percent):

Benefits	
Capital costs	
Running costs	

Inland Empire Utilities Agency

Life Cycle Alternative Cost Analysis ($000s)
Alternative 2 - Bioscrubber+ Activated Carbon

	Year																													
	2016	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**
Expressed in 2016 dollars, unescalated																														
Capital Outlays																														
Other	6,333,500																													
Other																														
Other																														
Other																														
Other																														
Other																														
Other																														
Total capital outlays	**6,333,500**																													
Benefits:																														
Other																														
Other																														
Other																														
Total benefits																														
Annual Running Costs:																														
Other								118,690	124,031	129,613	135,445	141,540	147,910	154,566	161,521	168,790	176,385	184,322	192,617	201,285	210,343	219,808	229,699	240,036	250,837	262,125	273,921	286,247	299,128	312,589
Other																														
Other																														
Other																														
Other																														
Other																														
Other																														
Other																														
Total running costs								**118,690**	**124,031**	**129,613**	**135,445**	**141,540**	**147,910**	**154,566**	**161,521**	**168,790**	**176,385**	**184,322**	**192,617**	**201,285**	**210,343**	**219,808**	**229,699**	**240,036**	**250,837**	**262,125**	**273,921**	**286,247**	**299,128**	**312,589**
R&R Costs:																														
Other																														
Other																														
Other																														
Other																														
Other																														
Total refurbishments																														
Net Benefit/(cost)	**(6,333,500)**							**(118,690)**	**(124,031)**	**(129,613)**	**(135,445)**	**(141,540)**	**(147,910)**	**(154,566)**	**(161,521)**	**(168,790)**	**(176,385)**	**(184,322)**	**(192,617)**	**(201,285)**	**(210,343)**	**(219,808)**	**(229,699)**	**(240,036)**	**(250,837)**	**(262,125)**	**(273,921)**	**(286,247)**	**(299,128)**	**(312,589)**
Expressed in escalated dollars with sensitivity adjustments																														
Capital Outlays																														
Other	6,333,500																													
Other																														
Other																														
Other																														
Other																														
Other																														
Other																														
Total capital outlays	**6,333,500**																													
Benefits:																														
Other																														
Other																														
Other																														
Total benefits																														
Annual Running Costs:																														
Other								145,974	157,119	169,115	182,027	195,925	210,884	226,985	244,315	262,969	283,046	304,657	327,917	352,954	379,902	408,908	440,128	473,731	509,901	548,832	590,735	635,838	684,384	736,636
Other																														
Other																														
Other																														
Other																														
Other																														
Other																														
Other																														
Total running costs								**145,974**	**157,119**	**169,115**	**182,027**	**195,925**	**210,884**	**226,985**	**244,315**	**262,969**	**283,046**	**304,657**	**327,917**	**352,954**	**379,902**	**408,908**	**440,128**	**473,731**	**509,901**	**548,832**	**590,735**	**635,838**	**684,384**	**736,636**
R&R Costs:																														
Other																														
Other																														
Other																														
Other																														
Other																														
Total refurbishments																														
Net escalated benefit/(cost)	**(6,333,500)**							**(145,974)**	**(157,119)**	**(169,115)**	**(182,027)**	**(195,925)**	**(210,884)**	**(226,985)**	**(244,315)**	**(262,969)**	**(283,046)**	**(304,657)**	**(327,917)**	**(352,954)**	**(379,902)**	**(408,908)**	**(440,128)**	**(473,731)**	**(509,901)**	**(548,832)**	**(590,735)**	**(635,838)**	**(684,384)**	**(736,636)**
Life cycle cost analysis																														
PVs in 2016	(6,333,500)							(127,079)	(134,100)	(141,508)	(149,326)	(157,575)	(166,281)	(175,467)	(185,160)	(195,390)	(206,184)	(217,575)	(229,594)	(242,278)	(255,663)	(269,787)	(284,692)	(300,420)	(317,016)	(334,530)	(353,011)	(372,513)	(393,093)	(414,809)
NPV as of 2016	**(11,956,550)**																													

Inland Empire Utilities Agency

Life Cycle Alternative Cost Analysis ($000s)
Alternative 3 - Activated Carbon

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2016	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	2.00%	Running costs	

	Year																													
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Expressed in 2016 dollars, unescalated																														
Capital Outlays																														
Other	2,995,574																													
Other																														
Other																														
Other																														
Other																														
Other																														
Total capital outlays	**2,995,574**																													
Benefits:																														
Other																														
Other																														
Other																														
Total benefits																														
Annual Running Costs:																														
Other								75,936	79,353	82,924	86,655	90,555	94,630	98,888	103,338	107,988	112,848	117,926	123,233	128,778	134,573	140,629	146,957	153,570	160,481	167,703	175,249	183,135	191,376	199,988
Other																														
Other																														
Other																														
Other																														
Other																														
Other																														
Other																														
Total running costs								**75,936**	**79,353**	**82,924**	**86,655**	**90,555**	**94,630**	**98,888**	**103,338**	**107,988**	**112,848**	**117,926**	**123,233**	**128,778**	**134,573**	**140,629**	**146,957**	**153,570**	**160,481**	**167,703**	**175,249**	**183,135**	**191,376**	**199,988**
R&R Costs:																														
Other																														
Other																														
Other																														
Other																														
Other																														
Total refurbishments																														
Net Benefit/(cost)	**(2,995,574)**							**(75,936)**	**(79,353)**	**(82,924)**	**(86,655)**	**(90,555)**	**(94,630)**	**(98,888)**	**(103,338)**	**(107,988)**	**(112,848)**	**(117,926)**	**(123,233)**	**(128,778)**	**(134,573)**	**(140,629)**	**(146,957)**	**(153,570)**	**(160,481)**	**(167,703)**	**(175,249)**	**(183,135)**	**(191,376)**	**(199,988)**
Expressed in escalated dollars with sensitivity adjustments																														
Capital Outlays																														
Other	2,995,574																													
Other																														
Other																														
Other																														
Other																														
Other																														
Total capital outlays	**2,995,574**																													
Benefits:																														
Other																														
Other																														
Other																														
Total benefits																														
Annual Running Costs:																														
Other								93,391	100,522	108,197	116,457	125,349	134,919	145,221	156,308	168,242	181,088	194,914	209,795	225,813	243,054	261,611	281,585	303,084	326,225	351,132	377,941	406,797	437,855	471,286
Other																														
Other																														
Other																														
Other																														
Other																														
Other																														
Other																														
Total running costs								**93,391**	**100,522**	**108,197**	**116,457**	**125,349**	**134,919**	**145,221**	**156,308**	**168,242**	**181,088**	**194,914**	**209,795**	**225,813**	**243,054**	**261,611**	**281,585**	**303,084**	**326,225**	**351,132**	**377,941**	**406,797**	**437,855**	**471,286**
R&R Costs:																														
Other																														
Other																														
Other																														
Other																														
Other																														
Total refurbishments																														
Net escalated benefit/(cost)	**(2,995,574)**							**(93,391)**	**(100,522)**	**(108,197)**	**(116,457)**	**(125,349)**	**(134,919)**	**(145,221)**	**(156,308)**	**(168,242)**	**(181,088)**	**(194,914)**	**(209,795)**	**(225,813)**	**(243,054)**	**(261,611)**	**(281,585)**	**(303,084)**	**(326,225)**	**(351,132)**	**(377,941)**	**(406,797)**	**(437,855)**	**(471,286)**
Life cycle cost analysis																														
PVs in 2016	(2,995,574)							(81,303)	(85,794)	(90,534)	(95,536)	(100,814)	(106,383)	(112,260)	(118,462)	(125,006)	(131,912)	(139,200)	(146,890)	(155,005)	(163,568)	(172,605)	(182,140)	(192,203)	(202,821)	(214,026)	(225,850)	(238,327)	(251,493)	(265,387)
NPV as of 2016	**(6,593,093)**																													

Inland Empire UTILITIES AGENCY

Inland Empire Utilities Agency
149055 - IEUA - RP5 - Waste Gas
Alternatives Net Present Value Analysis

Agency: Inland Empire Utilities Agency

Project/Problem: 149055 - IEUA - RP5 - Waste Gas

			Sensitivity Adjustments (%)			Results	
		Risk Premium	Benefits	Capital Costs	Running Costs	Capital Cost	NPV
Alternative 1A	Flare Combined Streams Duplex Treatment					$7,160,000	($13,436,746)
Alternative 2	Flare and Thermal Oxidizer					$8,030,000	($13,626,805)
Alternative 3	Flare Separate Streams					$6,370,000	($11,644,886)
Alternative 1B	Flare Combined Streams Merged Treatment					$4,630,000	($6,920,842)

Year of analysis: 2016
Escalation rate: 3.00%
Discount rate: 2.00%

Make entries in yellow cells only.

From Summary Sheet:

		Risk adjustments (+/- percent):	
Year of analysis	2016	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	2.00%	Running costs	

Inland Empire Utilities Agency
149055 - IEUA - RP5 - Waste Gas
Life Cycle Alternative Cost Analysis ($000s)
Alternative 1A - Flare Combined Streams Duplex Treatment

	Year																											
	2016	2017	2018	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
Expressed in 2016 dollars, unescalated																												
Capital Outlays																												
Total Capital				7,160,000																								
Other																												
Other																												
Total capital outlays				**7,160,000**																								
Benefits:																												
Other																												
Other																												
Total benefits																												
Annual Running Costs:																												
Waste Gas Electrical Demand					4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	
H2S Treatment Media Usage					31,772	32,984	34,249	35,439	36,630	37,821	39,012	40,202	40,930	41,657	42,384	43,111	43,838	44,628	45,419	46,209	46,999	47,790	48,390	48,991	49,592	50,192	50,793	
Waste Gas Operating Labor					35,064	35,064	35,064	35,064	35,064	35,064	35,064	35,064	35,064	35,064	35,064	35,064	35,064	35,064	35,064	35,064	35,064	35,064	35,064	35,064	35,064	35,064	35,064	
Assist Gas (Digester gas)					93,000	93,000	95,000	97,000	99,000	104,000	106,000	109,000	111,000	113,000	115,000	115,000	118,000	120,000	122,000	124,000	127,000	129,000	131,000	136,000	138,000	142,000	145,000	
Other																												
Other																												
Total running costs					**164,587**	**165,799**	**169,064**	**172,254**	**175,445**	**181,636**	**184,827**	**189,018**	**191,745**	**194,472**	**197,199**	**197,926**	**201,653**	**204,443**	**207,234**	**210,024**	**213,815**	**216,605**	**219,206**	**224,806**	**227,407**	**232,008**	**235,608**	
R&R Costs:																												
Other					12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	12,411	
Other																												
Total refurbishments					**12,411**	**12,411**	**12,411**	**12,411**	**12,411**	**12,411**	**12,411**	**12,411**	**12,411**	**12,411**	**12,411**	**12,411**	**12,411**	**12,411**	**12,411**	**12,411**	**12,411**	**12,411**	**12,411**	**12,411**	**12,411**	**12,411**	**12,411**	
Net Benefit/(cost)				(7,160,000)	(176,998)	(178,210)	(181,474)	(184,665)	(187,856)	(194,047)	(197,238)	(201,428)	(204,156)	(206,883)	(209,610)	(210,337)	(214,064)	(216,854)	(219,645)	(222,435)	(226,225)	(229,016)	(231,616)	(237,217)	(239,818)	(244,418)	(248,019)	
Expressed in escalated dollars with sensitivity adjustments																												
Capital Outlays																												
Total Capital				8,549,414																								
Other																												
Other																												
Total capital outlays				**8,549,414**																								
Benefits:																												
Other																												
Other																												
Total benefits																												
Annual Running Costs:																												
Waste Gas Electrical Demand					5,843	6,018	6,199	6,385	6,576	6,774	6,977	7,186	7,402	7,624	7,853	8,088	8,331	8,581	8,838	9,103	9,376	9,658	9,947	10,246	10,553	10,870	11,196	
H2S Treatment Media Usage					39,076	41,783	44,687	47,627	50,705	53,924	57,290	60,810	63,767	66,847	70,054	73,394	76,870	80,604	84,492	88,541	92,758	97,147	101,319	105,654	110,158	114,837	119,697	
Waste Gas Operating Labor					43,124	44,418	45,751	47,123	48,537	49,993	51,493	53,038	54,629	56,268	57,956	59,694	61,485	63,330	65,230	67,186	69,202	71,278	73,416	75,619	77,888	80,224	82,631	
Assist Gas (Digester gas)					114,378	117,810	123,953	130,360	137,039	148,279	155,665	164,872	172,934	181,332	190,077	195,780	206,914	216,733	226,956	237,597	250,645	262,230	274,285	293,296	306,538	324,886	341,702	
Other																												
Other																												
Total running costs					**202,421**	**210,029**	**220,590**	**231,495**	**242,857**	**258,969**	**271,424**	**285,906**	**298,732**	**312,070**	**325,940**	**336,956**	**353,600**	**369,248**	**385,516**	**402,428**	**421,981**	**440,313**	**458,968**	**484,815**	**505,136**	**530,816**	**555,226**	
R&R Costs:																												
Other					15,264	15,722	16,193	16,679	17,180	17,695	18,226	18,773	19,336	19,916	20,513	21,129	21,763	22,415	23,088	23,781	24,494	25,229	25,986	26,765	27,568	28,395	29,247	
Other																												
Total refurbishments					**15,264**	**15,722**	**16,193**	**16,679**	**17,180**	**17,695**	**18,226**	**18,773**	**19,336**	**19,916**	**20,513**	**21,129**	**21,763**	**22,415**	**23,088**	**23,781**	**24,494**	**25,229**	**25,986**	**26,765**	**27,568**	**28,395**	**29,247**	
Net escalated benefit/(cost)				(8,549,414)	(217,685)	(225,751)	(236,783)	(248,175)	(260,037)	(276,664)	(289,650)	(304,679)	(318,068)	(331,986)	(346,453)	(358,084)	(375,363)	(391,663)	(408,604)	(426,209)	(446,475)	(465,542)	(484,953)	(511,580)	(532,705)	(559,212)	(584,473)	
Life cycle cost analysis																												
PVs in 2016				(7,591,635)	(189,508)	(192,676)	(198,129)	(203,590)	(209,138)	(218,148)	(223,909)	(230,908)	(236,329)	(241,834)	(247,424)	(250,716)	(257,660)	(263,578)	(269,587)	(275,688)	(283,135)	(289,437)	(295,594)	(305,710)	(312,091)	(321,197)	(329,124)	
NPV as of 2016	**(13,436,746)**																											

Inland Empire Utilities Agency
149055 - IEUA - RP5 - Waste Gas
Life Cycle Alternative Cost Analysis ($000s)
Alternative 2 - Flare and Thermal Oxidizer

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2016	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	2.00%	Running costs	

	Year																											
	2016	2017	2018	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
Expressed in 2016 dollars, unescalated																												
Capital Outlays																												
Total Capital				8,030,000																								
Other																												
Other																												
Total capital outlays				**8,030,000**																								
Benefits:																												
Other																												
Other																												
Total benefits																												
Annual Running Costs:																												
Waste Gas Electrical Demand					12,266	12,266	12,266	12,266	12,266	12,266	12,266	12,266	12,266	12,266	12,266	12,266	12,266	12,266	12,266	12,266	12,266	12,266	12,266	12,266	12,266	12,266	12,266	
H2S Treatment Media Usage					31,477	32,677	33,930	35,110	36,289	37,469	38,649	39,829	40,549	41,269	41,990	42,710	43,430	44,213	44,996	45,779	46,562	47,345	47,940	48,536	49,131	49,726	50,321	
Waste Gas Operating Labor					70,128	70,128	70,128	70,128	70,128	70,128	70,128	70,128	70,128	70,128	70,128	70,128	70,128	70,128	70,128	70,128	70,128	70,128	70,128	70,128	70,128	70,128	70,128	
Assist Gas (Natural gas)					12,267	12,267	12,267	12,267	12,267	12,267	12,267	12,267	12,267	12,267	12,267	12,267	12,267	12,267	12,267	12,267	12,267	12,267	12,267	12,267	12,267	12,267	12,267	
Siloxane Treatment O&M					35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	
Other																												
Other																												
Total running costs					**161,138**	**162,339**	**163,591**	**164,771**	**165,951**	**167,131**	**168,310**	**169,490**	**170,210**	**170,931**	**171,651**	**172,372**	**173,092**	**173,875**	**174,658**	**175,441**	**176,224**	**177,007**	**177,602**	**178,197**	**178,792**	**179,387**	**179,982**	
R&R Costs:																												
Other					13,911	13,911	13,911	13,911	13,911	13,911	13,911	13,911	13,911	13,911	13,911	13,911	13,911	13,911	13,911	13,911	13,911	13,911	13,911	13,911	13,911	13,911	13,911	
Other																												
Total refurbishments					**13,911**	**13,911**	**13,911**	**13,911**	**13,911**	**13,911**	**13,911**	**13,911**	**13,911**	**13,911**	**13,911**	**13,911**	**13,911**	**13,911**	**13,911**	**13,911**	**13,911**	**13,911**	**13,911**	**13,911**	**13,911**	**13,911**	**13,911**	
Net Benefit/(cost)				**(8,030,000)**	**(175,049)**	**(176,250)**	**(177,502)**	**(178,682)**	**(179,862)**	**(181,042)**	**(182,221)**	**(183,401)**	**(184,121)**	**(184,842)**	**(185,562)**	**(186,282)**	**(187,003)**	**(187,786)**	**(188,569)**	**(189,352)**	**(190,135)**	**(190,918)**	**(191,513)**	**(192,108)**	**(192,703)**	**(193,298)**	**(193,893)**	
Expressed in escalated dollars with sensitivity adjustments																												
Capital Outlays																												
Total Capital				9,588,240																								
Other																												
Other																												
Total capital outlays				**9,588,240**																								
Benefits:																												
Other																												
Other																												
Total benefits																												
Annual Running Costs:																												
Waste Gas Electrical Demand					15,086	15,538	16,004	16,485	16,979	17,488	18,013	18,554	19,110	19,683	20,274	20,882	21,509	22,154	22,819	23,503	24,208	24,934	25,682	26,453	27,246	28,064	28,906	
H2S Treatment Media Usage					38,712	41,394	44,271	47,185	50,233	53,422	56,757	60,244	63,174	66,225	69,403	72,711	76,155	79,854	83,707	87,718	91,895	96,243	100,377	104,671	109,133	113,769	118,584	
Waste Gas Operating Labor					86,249	88,836	91,501	94,246	97,074	99,986	102,986	106,075	109,258	112,535	115,911	119,389	122,970	126,659	130,459	134,373	138,404	142,556	146,833	151,238	155,775	160,448	165,262	
Assist Gas (Natural gas)					15,087	15,540	16,006	16,486	16,981	17,490	18,015	18,555	19,112	19,685	20,276	20,884	21,511	22,156	22,821	23,505	24,210	24,937	25,685	26,455	27,249	28,066	28,908	
Siloxane Treatment O&M					43,046	44,337	45,667	47,037	48,448	49,902	51,399	52,941	54,529	56,165	57,850	59,585	61,373	63,214	65,110	67,064	69,076	71,148	73,282	75,481	77,745	80,077	82,480	
Other																												
Other																												
Total running costs					**198,180**	**205,646**	**213,450**	**221,439**	**229,715**	**238,288**	**247,169**	**256,369**	**265,182**	**274,294**	**283,713**	**293,451**	**303,518**	**314,037**	**324,915**	**336,163**	**347,793**	**359,819**	**371,859**	**384,298**	**397,149**	**410,425**	**424,140**	
R&R Costs:																												
Other					17,109	17,622	18,151	18,695	19,256	19,834	20,429	21,041	21,673	22,323	22,993	23,682	24,393	25,125	25,878	26,655	27,454	28,278	29,126	30,000	30,900	31,827	32,782	
Other																												
Total refurbishments					**17,109**	**17,622**	**18,151**	**18,695**	**19,256**	**19,834**	**20,429**	**21,041**	**21,673**	**22,323**	**22,993**	**23,682**	**24,393**	**25,125**	**25,878**	**26,655**	**27,454**	**28,278**	**29,126**	**30,000**	**30,900**	**31,827**	**32,782**	
Net escalated benefit/(cost)				**(9,588,240)**	**(215,288)**	**(223,268)**	**(231,600)**	**(240,134)**	**(248,971)**	**(258,122)**	**(267,598)**	**(277,410)**	**(286,855)**	**(296,617)**	**(306,706)**	**(317,133)**	**(327,910)**	**(339,162)**	**(350,793)**	**(362,818)**	**(375,247)**	**(388,097)**	**(400,985)**	**(414,298)**	**(428,049)**	**(442,252)**	**(456,922)**	
Life cycle cost analysis																												
PVs in 2016				(8,514,083)	(187,421)	(190,557)	(193,793)	(196,993)	(200,238)	(203,527)	(206,862)	(210,242)	(213,138)	(216,069)	(219,038)	(222,044)	(225,088)	(228,246)	(231,445)	(234,685)	(237,965)	(241,288)	(244,413)	(247,576)	(250,778)	(254,018)	(257,298)	
NPV as of 2016	**(13,626,805)**																											

Inland Empire Utilities Agency
149055 - IEUA - RP5 - Waste Gas
Life Cycle Alternative Cost Analysis ($000s)
Alternative 3 - Flare Separate Streams

From Summary Sheet:		**Risk adjustments (+/- percent):**	
Year of analysis	2016	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	2.00%	Running costs	

Year	2016	2017	2018	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Expressed in 2016 dollars, unescalated															
Capital Outlays															
Total Capital				6,370,000											
Other															
Other															
Total capital outlays				**6,370,000**											
Benefits:															
Other															
Other															
Total benefits															
Annual Running Costs:															
Waste Gas Electrical Demand					4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751
H2S Treatment Media Usage					31,477	32,677	33,930	35,110	36,289	37,469	38,649	39,829	40,549	41,269	41,990
Waste Gas Operating Labor					35,064	35,064	35,064	35,064	35,064	35,064	35,064	35,064	35,064	35,064	35,064
Assist Gas (Natural gas)					64,712	68,307	68,307	71,902	71,902	75,497	75,497	79,092	79,092	82,687	82,687
Other															
Other															
Total running costs					**136,004**	**140,799**	**142,052**	**146,827**	**148,007**	**152,781**	**153,961**	**158,736**	**159,456**	**163,772**	**164,492**
R&R Costs:															
Other					11,041	11,041	11,041	11,041	11,041	11,041	11,041	11,041	11,041	11,041	11,041
Other															
Total refurbishments					**11,041**	**11,041**	**11,041**	**11,041**	**11,041**	**11,041**	**11,041**	**11,041**	**11,041**	**11,041**	**11,041**
Net Benefit/(cost)				**(6,370,000)**	**(147,045)**	**(151,841)**	**(153,093)**	**(157,868)**	**(159,048)**	**(163,823)**	**(165,002)**	**(169,777)**	**(170,498)**	**(174,813)**	**(175,533)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Total Capital				7,606,113											
Other															
Other															
Total capital outlays				**7,606,113**											
Benefits:															
Other															
Other															
Total benefits															
Annual Running Costs:															
Waste Gas Electrical Demand					5,843	6,018	6,199	6,385	6,576	6,774	6,977	7,186	7,402	7,624	7,853
H2S Treatment Media Usage					38,712	41,394	44,271	47,185	50,233	53,422	56,757	60,244	63,174	66,225	69,403
Waste Gas Operating Labor					43,124	44,418	45,751	47,123	48,537	49,993	51,493	53,038	54,629	56,268	57,956
Assist Gas (Natural gas)					79,587	86,529	89,125	96,630	99,529	107,641	110,870	119,634	123,223	132,689	136,670
Other															
Other															
Total running costs					**167,267**	**178,360**	**185,346**	**197,323**	**204,876**	**217,830**	**226,097**	**240,102**	**248,428**	**262,806**	**271,880**
R&R Costs:															
Other					13,579	13,987	14,406	14,839	15,284	15,742	16,215	16,701	17,202	17,718	18,250
Other															
Total refurbishments					**13,579**	**13,987**	**14,406**	**14,839**	**15,284**	**15,742**	**16,215**	**16,701**	**17,202**	**17,718**	**18,250**
Net escalated benefit/(cost)				(7,606,113)	(180,847)	(192,347)	(199,752)	(212,162)	(220,159)	(233,572)	(242,312)	(256,803)	(265,630)	(280,524)	(290,130)
Life cycle cost analysis															
PVs in 2016				(6,754,011)	(157,438)	(164,166)	(167,144)	(174,046)	(177,066)	(184,170)	(187,315)	(194,625)	(197,367)	(204,346)	(207,200)
NPV as of 2016	**(11,644,886)**														

Year	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
Expressed in 2016 dollars, unescalated													
Capital Outlays													
Total Capital													
Other													
Other													
Total capital outlays													
Benefits:													
Other													
Other													
Total benefits													
Annual Running Costs:													
Waste Gas Electrical Demand	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	
H2S Treatment Media Usage	42,710	43,430	44,213	44,996	45,779	46,562	47,345	47,940	48,536	49,131	49,726	50,321	
Waste Gas Operating Labor	35,064	35,064	35,064	35,064	35,064	35,064	35,064	35,064	35,064	35,064	35,064	35,064	
Assist Gas (Natural gas)	82,687	86,282	86,282	86,282	89,878	89,878	93,473	93,473	97,068	100,663	100,663	104,258	
Other													
Other													
Total running costs	**165,212**	**169,528**	**170,311**	**171,094**	**175,472**	**176,255**	**180,633**	**181,228**	**185,418**	**189,609**	**190,204**	**194,394**	
R&R Costs:													
Other	11,041	11,041	11,041	11,041	11,041	11,041	11,041	11,041	11,041	11,041	11,041	11,041	
Other													
Total refurbishments	**11,041**	**11,041**	**11,041**	**11,041**	**11,041**	**11,041**	**11,041**	**11,041**	**11,041**	**11,041**	**11,041**	**11,041**	
Net Benefit/(cost)	**(176,254)**	**(180,569)**	**(181,352)**	**(182,135)**	**(186,513)**	**(187,296)**	**(191,674)**	**(192,270)**	**(196,460)**	**(200,650)**	**(201,245)**	**(205,435)**	
Expressed in escalated dollars with sensitivity adjustments													
Capital Outlays													
Total Capital													
Other													
Other													
Total capital outlays													
Benefits:													
Other													
Other													
Total benefits													
Annual Running Costs:													
Waste Gas Electrical Demand	8,088	8,331	8,581	8,838	9,103	9,376	9,658	9,947	10,246	10,553	10,870	11,196	
H2S Treatment Media Usage	72,711	76,155	79,854	83,707	87,718	91,895	96,243	100,377	104,671	109,133	113,769	118,584	
Waste Gas Operating Labor	59,694	61,485	63,330	65,230	67,186	69,202	71,278	73,416	75,619	77,888	80,224	82,631	
Assist Gas (Natural gas)	140,770	151,297	155,836	160,511	172,215	177,381	190,011	195,711	209,336	223,601	230,309	245,691	
Other													
Other													
Total running costs	**281,263**	**297,268**	**307,601**	**318,285**	**336,223**	**347,855**	**367,190**	**379,452**	**399,872**	**421,175**	**435,172**	**458,102**	
R&R Costs:													
Other	18,797	19,361	19,942	20,540	21,156	21,791	22,445	23,118	23,812	24,526	25,262	26,020	
Other													
Total refurbishments	**18,797**	**19,361**	**19,942**	**20,540**	**21,156**	**21,791**	**22,445**	**23,118**	**23,812**	**24,526**	**25,262**	**26,020**	
Net escalated benefit/(cost)	(300,060)	(316,629)	(327,542)	(338,825)	(357,379)	(369,646)	(389,635)	(402,570)	(423,683)	(445,701)	(460,434)	(484,121)	
Life cycle cost analysis													
PVs in 2016	(210,090)	(217,344)	(220,427)	(223,549)	(231,167)	(234,413)	(242,244)	(245,379)	(253,184)	(261,120)	(264,462)	(272,615)	

From Summary Sheet:

Year of analysis	**2016**	**Benefits**	
Escalation rate	**3.00%**	**Capital costs**	
Discount rate	**2.00%**	**Running costs**	

Risk adjustments (+/- percent):

Inland Empire Utilities Agency
149055 - IEUA - RP5 - Waste Gas
Life Cycle Alternative Cost Analysis ($000s)
Alternative 1B - Flare Combined Streams Merged Treatment

Expressed in 2016 dollars, unescalated

Year	2016	2017	2018	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
Capital Outlays																												
Total Capital				4,630,000																								
Other																												
Other																												
Total capital outlays				**4,630,000**																								
Benefits:																												
Other																												
Other																												
Total benefits																												
Annual Running Costs:																												
Waste Gas Electrical Demand					4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	4,751	
H2S Treatment Media Usage					31,772	32,984	34,249	35,439	36,630	37,821	39,012	40,202	40,930	41,657	42,384	43,111	43,838	44,628	45,419	46,209	46,999	47,790	48,390	48,991	49,592	50,192	50,793	
Waste Gas Operating Labor					17,532	17,532	17,532	17,532	17,532	17,532	17,532	17,532	17,532	17,532	17,532	17,532	17,532	17,532	17,532	17,532	17,532	17,532	17,532	17,532	17,532	17,532	17,532	
Other																												
Other																												
Total running costs					**54,055**	**55,267**	**56,531**	**57,722**	**58,913**	**60,104**	**61,295**	**62,485**	**63,213**	**63,940**	**64,667**	**65,394**	**66,121**	**66,911**	**67,702**	**68,492**	**69,282**	**70,073**	**70,673**	**71,274**	**71,875**	**72,475**	**73,076**	
R&R Costs:																												
Other					8,015	8,015	8,015	8,015	8,015	8,015	8,015	8,015	8,015	8,015	8,015	8,015	8,015	8,015	8,015	8,015	8,015	8,015	8,015	8,015	8,015	8,015	8,015	
Other																												
Total refurbishments					**8,015**	**8,015**	**8,015**	**8,015**	**8,015**	**8,015**	**8,015**	**8,015**	**8,015**	**8,015**	**8,015**	**8,015**	**8,015**	**8,015**	**8,015**	**8,015**	**8,015**	**8,015**	**8,015**	**8,015**	**8,015**	**8,015**	**8,015**	
Net Benefit/(cost)				**(4,630,000)**	**(62,070)**	**(63,282)**	**(64,547)**	**(65,737)**	**(66,928)**	**(68,119)**	**(69,310)**	**(70,501)**	**(71,228)**	**(71,955)**	**(72,682)**	**(73,409)**	**(74,136)**	**(74,927)**	**(75,717)**	**(76,507)**	**(77,298)**	**(78,088)**	**(78,689)**	**(79,289)**	**(79,890)**	**(80,491)**	**(81,091)**	

Expressed in escalated dollars with sensitivity adjustments

	2016	2017	2018	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
Capital Outlays																												
Total Capital				5,528,462																								
Other																												
Other																												
Total capital outlays				**5,528,462**																								
Benefits:																												
Other																												
Other																												
Total benefits																												
Annual Running Costs:																												
Waste Gas Electrical Demand					5,843	6,018	6,199	6,385	6,576	6,774	6,977	7,186	7,402	7,624	7,853	8,088	8,331	8,581	8,838	9,103	9,376	9,658	9,947	10,246	10,553	10,870	11,196	
H2S Treatment Media Usage					39,076	41,783	44,687	47,627	50,705	53,924	57,290	60,810	63,767	66,847	70,054	73,394	76,870	80,604	84,492	88,541	92,758	97,147	101,319	105,654	110,158	114,837	119,697	
Waste Gas Operating Labor					21,562	22,209	22,875	23,562	24,268	24,997	25,746	26,519	27,314	28,134	28,978	29,847	30,743	31,665	32,615	33,593	34,601	35,639	36,708	37,809	38,944	40,112	41,315	
Other																												
Other																												
Total running costs					**66,481**	**70,010**	**73,761**	**77,574**	**81,549**	**85,694**	**90,013**	**94,515**	**98,483**	**102,604**	**106,884**	**111,329**	**115,944**	**120,849**	**125,945**	**131,238**	**136,735**	**142,444**	**147,975**	**153,709**	**159,655**	**165,819**	**172,209**	
R&R Costs:																												
Other					9,858	10,153	10,458	10,772	11,095	11,428	11,771	12,124	12,487	12,862	13,248	13,645	14,055	14,476	14,911	15,358	15,819	16,293	16,782	17,286	17,804	18,338	18,888	
Other																												
Total refurbishments					**9,858**	**10,153**	**10,458**	**10,772**	**11,095**	**11,428**	**11,771**	**12,124**	**12,487**	**12,862**	**13,248**	**13,645**	**14,055**	**14,476**	**14,911**	**15,358**	**15,819**	**16,293**	**16,782**	**17,286**	**17,804**	**18,338**	**18,888**	
Net escalated benefit/(cost)				**(5,528,462)**	**(76,339)**	**(80,164)**	**(84,219)**	**(88,346)**	**(92,644)**	**(97,122)**	**(101,784)**	**(106,639)**	**(110,971)**	**(115,467)**	**(120,132)**	**(124,974)**	**(129,998)**	**(135,326)**	**(140,856)**	**(146,596)**	**(152,554)**	**(158,737)**	**(164,757)**	**(170,995)**	**(177,459)**	**(184,157)**	**(191,097)**	

Life cycle cost analysis

	2016	2017	2018	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
PVs in 2016				(4,909,116)	(66,457)	(68,419)	(70,471)	(72,474)	(74,510)	(76,580)	(78,682)	(80,819)	(82,453)	(84,111)	(85,794)	(87,502)	(89,235)	(91,070)	(92,933)	(94,824)	(96,743)	(98,690)	(100,424)	(102,183)	(103,966)	(105,775)	(107,609)	
NPV as of 2016	**(6,920,842)**																											

RP-5 Food Waste

Inland Empire
UTILITIES AGENCY

			Results ($000s)		
Agency:	Inland Empire Utilities Agency				
Project/Problem:			Capital Cost	30-year NPV	Benefit over 'Do Nothing'
Alternative 1	**FW Alt 1**		$134,500,000	($283,824,619)	
Alternative 2	**FW Alt 2**		$153,700,000	($303,508,513)	($19,683,894)
Alternative 3	**FW Alt 3**		$146,400,000	($331,463,251)	($47,638,632)
Alternative 4					
Alternative 5					
Alternative 6					
Alternative 7					
Alternative 8					
Alternative 9					
Alternative 10					
Alternative 11					
Alternative 12					

Year of analysis:	2016
Escalation rate:	3.00%
Discount rate:	2.00%

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2016	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	2.00%	Running costs	

Inland Empire Utilities Agency

Life Cycle Alternative Cost Analysis ($000s)

Alternative 1 - FW Alt 1

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Expressed in 2016 dollars, unescalated															
Capital Outlays															
FW-Alt-1			13,450,000	13,450,000	13,450,000	26,900,000	26,900,000	40,350,000							
Other															
Other															
Other															
Total capital outlays			**13,450,000**	**13,450,000**	**13,450,000**	**26,900,000**	**26,900,000**	**40,350,000**							
Benefits:															
Power								1,285,623	1,304,282	1,322,940	1,369,075	1,415,211	1,461,346	1,507,481	1,553,617
Heat								129,830	133,284	136,737	140,191	143,644	147,098	150,552	154,005
Other															
Total benefits								**1,415,453**	**1,437,565**	**1,459,677**	**1,509,266**	**1,558,855**	**1,608,444**	**1,658,033**	**1,707,622**
Annual Running Costs:															
O&M								4,999,291	5,036,509	5,073,727	5,165,763	5,257,799	5,349,835	5,441,871	5,967,707
Other															
Other															
Labor															
Other															
Other															
Other															
Other															
Total running costs								**4,999,291**	**5,036,509**	**5,073,727**	**5,165,763**	**5,257,799**	**5,349,835**	**5,441,871**	**5,967,707**
R&R Costs:															
General Repair and Replacement								663,000	663,000	663,000	663,000	663,000	663,000	663,000	663,000
Other															
Other															
Other															
Other															
Total refurbishments								**663,000**	**663,000**	**663,000**	**663,000**	**663,000**	**663,000**	**663,000**	**663,000**
Net Benefit/(cost)			**(13,450,000)**	**(13,450,000)**	**(13,450,000)**	**(26,900,000)**	**(26,900,000)**	**(44,596,838)**	**(4,261,944)**	**(4,277,050)**	**(4,319,497)**	**(4,361,944)**	**(4,404,391)**	**(4,446,838)**	**(4,923,085)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
FW-Alt-1			14,269,105	14,697,178	15,138,093	31,184,473	32,120,007	49,625,410							
Other															
Other															
Other															
Total capital outlays			**14,269,105**	**14,697,178**	**15,138,093**	**31,184,473**	**32,120,007**	**49,625,410**							
Benefits:															
Power								1,581,154	1,652,225	1,726,137	1,839,923	1,958,983	2,083,530	2,213,787	2,349,985
Heat								159,675	168,840	178,411	188,405	198,838	209,727	221,090	232,947
Other															
Total benefits								**1,740,829**	**1,821,065**	**1,904,548**	**2,028,328**	**2,157,820**	**2,293,257**	**2,434,877**	**2,582,931**
Annual Running Costs:															
O&M								6,148,497	6,380,099	6,620,063	6,942,354	7,278,024	7,627,585	7,991,571	9,026,692
Other															
Other															
Labor															
Other															
Other															
Other															
Other															
Total running costs								**6,148,497**	**6,380,099**	**6,620,063**	**6,942,354**	**7,278,024**	**7,627,585**	**7,991,571**	**9,026,692**
R&R Costs:															
General Repair and Replacement								815,406	839,869	865,065	891,017	917,747	945,279	973,638	1,002,847
Other															
Other															
Other															
Other															
Total refurbishments								**815,406**	**839,869**	**865,065**	**891,017**	**917,747**	**945,279**	**973,638**	**1,002,847**
Net escalated benefit/(cost)			**(14,269,105)**	**(14,697,178)**	**(15,138,093)**	**(31,184,473)**	**(32,120,007)**	**(54,848,485)**	**(5,398,903)**	**(5,580,580)**	**(5,805,043)**	**(6,037,950)**	**(6,279,608)**	**(6,530,331)**	**(7,446,607)**
Life cycle cost analysis															
PVs in 2016			(13,715,018)	(13,849,479)	(13,985,258)	(28,244,738)	(28,521,647)	(47,748,907)	(4,607,912)	(4,669,580)	(4,762,157)	(4,856,100)	(4,951,428)	(5,048,158)	(5,643,598)
NPV as of 2016	**(283,824,619)**														

	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Expressed in 2016 dollars, unescalated															
Capital Outlays															
FW-Alt-1															
Other															
Other															
Other															
Total capital outlays															
Benefits:															
Power	1,581,865	1,610,113	1,638,361	1,666,609	1,694,857	1,725,442	1,756,027	1,786,612	1,817,196	1,847,781	1,870,849	1,893,917	1,916,984	1,940,052	1,963,120
Heat	157,459	160,913	164,366	167,820	171,273	174,078	176,883	179,688	182,493	185,298	188,103	190,908	193,713	196,518	199,323
Other															
Total benefits	**1,739,324**	**1,771,025**	**1,802,727**	**1,834,428**	**1,866,130**	**1,899,520**	**1,932,910**	**1,966,300**	**1,999,690**	**2,033,080**	**2,058,952**	**2,084,825**	**2,110,698**	**2,136,570**	**2,162,443**
Annual Running Costs:															
O&M	6,297,083	6,353,446	6,409,809	6,466,172	6,522,535	6,583,553	6,644,571	6,705,589	6,766,607	6,937,125	7,269,657	7,315,668	7,361,679	7,407,690	7,453,702
Other															
Other															
Labor															
Other															
Other															
Other															
Other															
Total running costs	**6,297,083**	**6,353,446**	**6,409,809**	**6,466,172**	**6,522,535**	**6,583,553**	**6,644,571**	**6,705,589**	**6,766,607**	**6,937,125**	**7,269,657**	**7,315,668**	**7,361,679**	**7,407,690**	**7,453,702**
R&R Costs:															
General Repair and Replacement	663,000	663,000	663,000	663,000	663,000	663,000	663,000	663,000	663,000	663,000	663,000	663,000	663,000	663,000	663,000
Other															
Other															
Other															
Other															
Total refurbishments	**663,000**	**663,000**	**663,000**	**663,000**	**663,000**	**663,000**	**663,000**	**663,000**	**663,000**	**663,000**	**663,000**	**663,000**	**663,000**	**663,000**	**663,000**
Net Benefit/(cost)	**(5,220,759)**	**(5,245,421)**	**(5,270,082)**	**(5,294,743)**	**(5,319,405)**	**(5,347,033)**	**(5,374,661)**	**(5,402,289)**	**(5,429,917)**	**(5,567,045)**	**(5,873,704)**	**(5,893,843)**	**(5,913,981)**	**(5,934,120)**	**(5,954,259)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
FW-Alt-1															
Other															
Other															
Other															
Total capital outlays															
Benefits:															
Power	2,464,494	2,583,758	2,707,961	2,837,290	2,971,941	3,116,339	3,266,727	3,423,332	3,586,394	3,756,159	3,917,143	4,084,404	4,258,176	4,438,699	4,626,220
Heat	245,316	258,217	271,672	285,702	300,329	314,405	329,055	344,301	360,166	376,673	393,847	411,711	430,293	449,620	469,719
Other															
Total benefits	**2,709,809**	**2,841,976**	**2,979,633**	**3,122,992**	**3,272,270**	**3,430,744**	**3,595,782**	**3,767,634**	**3,946,561**	**4,132,833**	**4,310,989**	**4,496,116**	**4,688,470**	**4,888,319**	**5,095,939**
Annual Running Costs:															
O&M	9,810,650	10,195,415	10,594,437	11,008,225	11,437,304	11,890,629	12,360,859	12,848,602	13,354,484	14,101,747	15,221,046	15,776,905	16,352,417	16,948,260	17,565,137
Other															
Other															
Labor															
Other															
Other															
Other															
Other															
Total running costs	**9,810,650**	**10,195,415**	**10,594,437**	**11,008,225**	**11,437,304**	**11,890,629**	**12,360,859**	**12,848,602**	**13,354,484**	**14,101,747**	**15,221,046**	**15,776,905**	**16,352,417**	**16,948,260**	**17,565,137**
R&R Costs:															
General Repair and Replacement	1,032,932	1,063,920	1,095,838	1,128,713	1,162,575	1,197,452	1,233,375	1,270,377	1,308,488	1,347,742	1,388,175	1,429,820	1,472,715	1,516,896	1,562,403
Other															
Other															
Other															
Other															
Total refurbishments	**1,032,932**	**1,063,920**	**1,095,838**	**1,128,713**	**1,162,575**	**1,197,452**	**1,233,375**	**1,270,377**	**1,308,488**	**1,347,742**	**1,388,175**	**1,429,820**	**1,472,715**	**1,516,896**	**1,562,403**
Net escalated benefit/(cost)	**(8,133,773)**	**(8,417,360)**	**(8,710,643)**	**(9,013,946)**	**(9,327,608)**	**(9,657,336)**	**(9,998,453)**	**(10,351,345)**	**(10,716,411)**	**(11,316,657)**	**(12,298,232)**	**(12,710,610)**	**(13,136,662)**	**(13,576,838)**	**(14,031,601)**
Life cycle cost analysis															
PVs in 2016	(6,043,513)	(6,131,591)	(6,220,815)	(6,311,199)	(6,402,757)	(6,499,110)	(6,596,737)	(6,695,654)	(6,795,876)	(7,035,809)	(7,496,152)	(7,595,597)	(7,696,272)	(7,798,190)	(7,901,367)

Total risk-adjusted capital outlays: $134,500,000

Alternative: 1
Row: 8

Summary!A8	Alternative
Summary!B8	Alt. number
Summary!C8	Alt. name
Summary!E8	Risk premium
Summary!G8	Benefit sens.
Summary!H8	Capital sens
Summary!I8	Running sens.

From Summary Sheet:

Year of analysis	2016		**Benefits**	
Escalation rate	3.00%		**Capital costs**	
Discount rate	2.00%		**Running costs**	

Risk adjustments (+/- percent):

Inland Empire Utilities Agency

Life Cycle Alternative Cost Analysis ($000s)
Alternative 2 - FW Alt 2

Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Expressed in 2016 dollars. unescalated															
Capital Outlays															
FW-Alt-2			15,370,000	15,370,000	15,370,000	30,740,000	30,740,000	46,110,000							
Other															
Other															
Other															
Other															
Other															
Total capital outlays			**15,370,000**	**15,370,000**	**15,370,000**	**30,740,000**	**30,740,000**	**46,110,000**							
Benefits:															
Power								2,271,686	2,304,103	2,336,521	2,413,962	2,491,404	2,568,845	2,646,287	2,723,728
Heat								129,830	133,284	136,737	140,191	143,644	147,098	150,552	154,005
SGIP Incentives															
Total benefits								**2,401,516**	**2,437,387**	**2,473,258**	**2,554,153**	**2,635,048**	**2,715,943**	**2,796,838**	**2,877,733**
Annual Running Costs:															
O&M								6,464,968	6,571,829	6,678,690	6,797,258	6,915,825	6,996,224	7,076,623	7,829,343
Labor															
Other															
Total running costs								**6,464,968**	**6,571,829**	**6,678,690**	**6,797,258**	**6,915,825**	**6,996,224**	**7,076,623**	**7,829,343**
R&R Costs:															
General Repair and Replacement								713,000	713,000	713,000	713,000	713,000	713,000	713,000	713,000
Other															
Total RR								**713,000**	**713,000**	**713,000**	**713,000**	**713,000**	**713,000**	**713,000**	**713,000**
Net Benefit/(cost)			**(15,370,000)**	**(15,370,000)**	**(15,370,000)**	**(30,740,000)**	**(30,740,000)**	**(50,886,452)**	**(4,847,442)**	**(4,918,432)**	**(4,956,104)**	**(4,993,777)**	**(4,993,281)**	**(4,992,785)**	**(5,664,609)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
FW-Alt-2			16,306,033	16,795,214	17,299,070	35,636,085	36,705,168	56,709,484							
Other															
Other															
Other															
Other															
Other															
Total capital outlays			**16,306,033**	**16,795,214**	**17,299,070**	**35,636,085**	**36,705,168**	**56,709,484**							
Benefits:															
Power								2,793,887	2,918,769	3,048,630	3,244,163	3,448,685	3,662,559	3,886,161	4,119,883
Heat								159,675	168,840	178,411	188,405	198,838	209,727	221,090	232,947
SGIP Incentives															
Total benefits								**2,953,562**	**3,087,609**	**3,227,041**	**3,432,568**	**3,647,523**	**3,872,286**	**4,107,251**	**4,352,830**
Annual Running Costs:															
O&M								7,951,096	8,324,997	8,714,176	9,134,946	9,573,119	9,974,943	10,392,260	11,842,583
Labor															
Other															
Total running costs								**7,951,096**	**8,324,997**	**8,714,176**	**9,134,946**	**9,573,119**	**9,974,943**	**10,392,260**	**11,842,583**
R&R Costs:															
General Repair and Replacement								876,900	903,207	930,303	958,212	986,959	1,016,568	1,047,065	1,078,476
Other															
Total RR								**876,900**	**903,207**	**930,303**	**958,212**	**986,959**	**1,016,568**	**1,047,065**	**1,078,476**
Net escalated benefit/(cost)			**(16,306,033)**	**(16,795,214)**	**(17,299,070)**	**(35,636,085)**	**(36,705,168)**	**(62,583,918)**	**(6,140,595)**	**(6,417,439)**	**(6,660,590)**	**(6,912,555)**	**(7,119,225)**	**(7,332,073)**	**(8,568,230)**
Life cycle cost analysis															
PVs in 2016			(15,672,850)	(15,826,505)	(15,981,667)	(32,276,700)	(32,593,138)	(54,483,067)	(5,240,939)	(5,369,825)	(5,464,004)	(5,559,512)	(5,613,460)	(5,667,931)	(6,493,647)
NPV as of 2016	**(303,508,513)**														

Year	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Expressed in 2016 dollars. unescalated															
Capital Outlays															
FW-Alt-2															
Other															
Other															
Other															
Other															
Other															
Total capital outlays															
Benefits:															
Power	2,771,745	2,819,762	2,867,779	2,915,796	2,956,500	2,956,500	2,956,500	2,956,500	2,956,500	2,956,500	2,956,500	2,956,500	2,956,500	2,956,500	2,956,500
Heat	157,459	160,913	164,366	167,820	171,273	174,078	176,883	179,688	182,493	185,298	188,103	190,908	193,713	196,518	199,323
SGIP Incentives															
Total benefits	**2,929,204**	**2,980,675**	**3,032,145**	**3,083,616**	**3,127,773**	**3,130,578**	**3,133,383**	**3,136,188**	**3,138,993**	**3,141,798**	**3,144,603**	**3,147,408**	**3,150,213**	**3,153,018**	**3,155,823**
Annual Running Costs:															
O&M	7,902,092	7,974,841	8,052,586	8,130,332	8,206,176	8,271,438	8,336,699	8,385,915	8,435,131	8,902,268	8,951,484	9,000,700	4,762,350	4,762,350	4,762,350
Labor															
Other															
Total running costs	**7,902,092**	**7,974,841**	**8,052,586**	**8,130,332**	**8,206,176**	**8,271,438**	**8,336,699**	**8,385,915**	**8,435,131**	**8,902,268**	**8,951,484**	**9,000,700**	**4,762,350**	**4,762,350**	**4,762,350**
R&R Costs:															
General Repair and Replacement	713,000	713,000	713,000	713,000	713,000	713,000	713,000	713,000	713,000	713,000	713,000	713,000	713,000	713,000	713,000
Other															
Total RR	**713,000**	**713,000**	**713,000**	**713,000**	**713,000**	**713,000**	**713,000**	**713,000**	**713,000**	**713,000**	**713,000**	**713,000**	**713,000**	**713,000**	**713,000**
Net Benefit/(cost)	**(5,685,888)**	**(5,707,166)**	**(5,733,441)**	**(5,759,716)**	**(5,791,403)**	**(5,853,859)**	**(5,916,316)**	**(5,962,727)**	**(6,009,138)**	**(6,473,469)**	**(6,519,881)**	**(6,566,292)**	**(2,325,137)**	**(2,322,332)**	**(2,319,527)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
FW-Alt-2															
Other															
Other															
Other															
Other															
Other															
Total capital outlays															
Benefits:															
Power	4,318,289	4,524,890	4,740,002	4,963,948	5,184,241	5,339,768	5,499,961	5,664,960	5,834,909	6,009,956	6,190,254	6,375,962	6,567,241	6,764,258	6,967,186
Heat	245,316	258,217	271,672	285,702	300,329	314,405	329,055	344,301	360,166	376,673	393,847	411,711	430,293	449,620	469,719
SGIP Incentives															
Total benefits	**4,563,604**	**4,783,108**	**5,011,674**	**5,249,650**	**5,484,570**	**5,654,173**	**5,829,016**	**6,009,261**	**6,195,075**	**6,386,629**	**6,584,101**	**6,787,673**	**6,997,534**	**7,213,878**	**7,436,904**
Annual Running Costs:															
O&M	12,311,201	12,797,278	13,309,698	13,841,346	14,389,580	14,939,136	15,508,716	16,068,281	16,647,462	18,096,477	18,742,419	19,410,831	10,578,556	10,895,912	11,222,790
Labor															
Other															
Total running costs	**12,311,201**	**12,797,278**	**13,309,698**	**13,841,346**	**14,389,580**	**14,939,136**	**15,508,716**	**16,068,281**	**16,647,462**	**18,096,477**	**18,742,419**	**19,410,831**	**10,578,556**	**10,895,912**	**11,222,790**
R&R Costs:															
General Repair and Replacement	1,110,831	1,144,156	1,178,480	1,213,835	1,250,250	1,287,757	1,326,390	1,366,182	1,407,167	1,449,382	1,492,864	1,537,650	1,583,779	1,631,292	1,680,231
Other															
Total RR	**1,110,831**	**1,144,156**	**1,178,480**	**1,213,835**	**1,250,250**	**1,287,757**	**1,326,390**	**1,366,182**	**1,407,167**	**1,449,382**	**1,492,864**	**1,537,650**	**1,583,779**	**1,631,292**	**1,680,231**
Net escalated benefit/(cost)	**(8,858,428)**	**(9,158,326)**	**(9,476,505)**	**(9,805,531)**	**(10,155,260)**	**(10,572,721)**	**(11,006,090)**	**(11,425,201)**	**(11,859,554)**	**(13,159,230)**	**(13,651,182)**	**(14,160,807)**	**(5,164,800)**	**(5,313,327)**	**(5,466,116)**
Life cycle cost analysis															
PVs in 2016	(6,581,942)	(6,671,344)	(6,767,765)	(6,865,435)	(6,970,883)	(7,115,138)	(7,261,552)	(7,390,266)	(7,520,806)	(8,181,376)	(8,320,817)	(8,462,205)	(3,025,861)	(3,051,840)	(3,078,037)

Total risk-adjusted capital outlays: $153,700,000

Alternative: 2
Row: 9

Summary!A9	Alternative
Summary!B9	Alt. number
Summary!C9	Alt. name
Summary!E9	Risk premium
Summary!G9	Benefit sens.
Summary!H9	Capital sens
Summary!I9	Running sens.

From Summary Sheet:

Year of analysis	2016
Escalation rate	3.00%
Discount rate	2.00%

Risk adjustments (+/- percent):

Benefits	
Capital costs	
Running costs	

Inland Empire Utilities Agency

Life Cycle Alternative Cost Analysis ($000s)
Alternative 3 - FW Alt 3

Year

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Expressed in 2016 dollars, unescalated															
Capital Outlays															
FW-Alt-3			14,640,000	14,640,000	14,640,000	29,280,000	29,280,000	43,920,000							
Other															
Other															
Other															
Total capital outlays			14.640.000	14.640.000	14.640.000	29.280.000	29.280.000	43.920.000							
Benefits:															
Power								2,956,500	2,956,500	2,956,500	2,956,500	2,956,500	2,956,500	2,956,500	2,956,500
Heat								129,830	133,284	136,737	140,191	143,644	147,098	150,552	154,005
Total benefits								3.086.330	3.089.784	3.093.237	3.096.691	3.100.144	3.103.598	3.107.052	3.110.505
Annual Running Costs:															
O&M								7,408,847	7,453,225	7,497,603	7,585,646	7,673,690	7,761,733	7,849,776	8,371,620
Other															
Other															
Total running costs								7.408.847	7.453.225	7.497.603	7.585.646	7.673.690	7.761.733	7.849.776	8.371.620
R&R Costs:															
Parts replacement								833,000	833,000	833,000	833,000	833,000	833,000	833,000	833,000
Other															
Other															
Other															
Total refurbishments								833.000	833.000	833.000	833.000	833.000	833.000	833.000	833.000
Net Benefit/(cost)			(14.640.000)	(14.640.000)	(14.640.000)	(29.280.000)	(29.280.000)	(49.075.517)	(5.196.441)	(5.237.365)	(5.321.955)	(5.406.545)	(5.491.135)	(5.575.725)	(6.094.114)
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
FW-Alt-3			15,531,576	15,997,523	16,477,449	33,943,545	34,961,851	54,016,060							
Other															
Other															
Other															
Total capital outlays			15.531.576	15.997.523	16.477.449	33.943.545	34.961.851	54.016.060							
Benefits:															
Power								3,636,122	3,745,206	3,857,562	3,973,289	4,092,487	4,215,262	4,341,720	4,471,972
Heat								159,675	168,840	178,411	188,405	198,838	209,727	221,090	232,947
Total benefits								3.795.797	3.914.045	4.035.973	4.161.694	4.291.325	4.424.989	4.562.810	4.704.918
Annual Running Costs:															
O&M								9,111,948	9,441,523	9,782,671	10,194,474	10,622,181	11,066,375	11,527,661	12,662,826
Other															
Other															
Total running costs								9.111.948	9.441.523	9.782.671	10.194.474	10.622.181	11.066.375	11.527.661	12.662.826
R&R Costs:															
Parts replacement								1,024,485	1,055,219	1,086,876	1,119,482	1,153,067	1,187,659	1,223,289	1,259,987
Other															
Other															
Other															
Total refurbishments								1.024.485	1.055.219	1.086.876	1.119.482	1.153.067	1.187.659	1.223.289	1.259.987
Net escalated benefit/(cost)			(15.531.576)	(15.997.523)	(16.477.449)	(33.943.545)	(34.961.851)	(60.356.696)	(6.582.697)	(6.833.574)	(7.152.263)	(7.483.923)	(7.829.045)	(8.188.140)	(9.217.895)
Life cycle cost analysis															
PVs in 2016			(14,928,466)	(15,074,823)	(15,222,616)	(30,743,714)	(31,045,123)	(52,544,136)	(5,618,268)	(5,718,029)	(5,867,347)	(6,019,043)	(6,173,149)	(6,329,698)	(6,986,012)
NPV as of 2016	(331.463.251)														

	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Expressed in 2016 dollars, unescalated															
Capital Outlays															
FW-Alt-3															
Other															
Other															
Other															
Total capital outlays															
Benefits:															
Power	2,956,500	2,956,500	2,956,500	2,956,500	2,956,500	2,956,500	2,956,500	2,956,500	2,956,500	2,956,500	2,956,500	2,956,500	2,956,500	2,956,500	2,956,500
Heat	157,459	160,913	164,366	167,820	171,273	174,078	176,883	179,688	182,493	185,298	188,103	190,908	193,713	196,518	199,323
Total benefits	3.113.959	3.117.413	3.120.866	3.124.320	3.127.773	3.130.578	3.133.383	3.136.188	3.138.993	3.141.798	3.144.603	3.147.408	3.150.213	3.153.018	3.155.823
Annual Running Costs:															
O&M	8,689,161	8,746,182	8,803,203	8,860,225	8,917,246	8,978,315	9,039,383	9,100,452	9,161,521	9,332,090	9,666,639	9,714,669	9,762,699	9,810,728	9,858,758
Other															
Other															
Total running costs	8.689.161	8.746.182	8.803.203	8.860.225	8.917.246	8.978.315	9.039.383	9.100.452	9.161.521	9.332.090	9.666.639	9.714.669	9.762.699	9.810.728	9.858.758
R&R Costs:															
Parts replacement	833,000	833,000	833,000	833,000	833,000	833,000	833,000	833,000	833,000	833,000	833,000	833,000	833,000	833,000	833,000
Other															
Other															
Other															
Total refurbishments	833.000	833.000	833.000	833.000	833.000	833.000	833.000	833.000	833.000	833.000	833.000	833.000	833.000	833.000	833.000
Net Benefit/(cost)	(6.408.202)	(6.461.770)	(6.515.337)	(6.568.905)	(6.622.473)	(6.680.736)	(6.739.000)	(6.797.264)	(6.855.528)	(7.023.291)	(7.355.036)	(7.400.261)	(7.445.485)	(7.490.710)	(7.535.935)
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
FW-Alt-3															
Other															
Other															
Other															
Total capital outlays															
Benefits:															
Power	4,606,131	4,744,315	4,886,644	5,033,243	5,184,241	5,339,768	5,499,961	5,664,960	5,834,909	6,009,956	6,190,254	6,375,962	6,567,241	6,764,258	6,967,186
Heat	245,316	258,217	271,672	285,702	300,329	314,405	329,055	344,301	360,166	376,673	393,847	411,711	430,293	449,620	469,719
Total benefits	4.851.447	5.002.532	5.158.316	5.318.945	5.484.570	5.654.173	5.829.016	6.009.261	6.195.075	6.386.629	6.584.101	6.787.673	6.997.534	7.213.878	7.436.904
Annual Running Costs:															
O&M	13,537,430	14,035,055	14,550,354	15,083,939	15,636,445	16,215,835	16,815,916	17,437,407	18,081,054	18,970,217	20,239,796	20,950,570	21,685,775	22,446,237	23,232,809
Other															
Other															
Total running costs	13.537.430	14.035.055	14.550.354	15.083.939	15.636.445	16.215.835	16.815.916	17.437.407	18.081.054	18.970.217	20.239.796	20.950.570	21.685.775	22.446.237	23.232.809
R&R Costs:															
Parts replacement	1,297,787	1,336,720	1,376,822	1,418,127	1,460,671	1,504,491	1,549,625	1,596,114	1,643,998	1,693,317	1,744,117	1,796,441	1,850,334	1,905,844	1,963,019
Other															
Other															
Other															
Total refurbishments	1.297.787	1.336.720	1.376.822	1.418.127	1.460.671	1.504.491	1.549.625	1.596.114	1.643.998	1.693.317	1.744.117	1.796.441	1.850.334	1.905.844	1.963.019
Net escalated benefit/(cost)	(9.983.770)	(10.369.243)	(10.768.860)	(11.183.121)	(11.612.546)	(12.066.153)	(12.536.525)	(13.024.260)	(13.529.977)	(14.276.905)	(15.399.812)	(15.959.337)	(16.538.575)	(17.138.203)	(17.758.924)
Life cycle cost analysis															
PVs in 2016	(7,418,088)	(7,553,432)	(7,690,717)	(7,829,967)	(7,971,209)	(8,120,175)	(8,271,296)	(8,424,600)	(8,580,115)	(8,876,259)	(9,386,661)	(9,536,969)	(9,689,323)	(9,843,747)	(10,000,268)

RP-5 Digester Gas Utilization

Inland Empire Utilities Agency

Inland Empire
UTILITIES AGENCY

Alternatives Net Present Value Analysis

		Results ($000s)		
Agency:	Inland Empire Utilities Agency	Capital Cost	30-year NPV	Benefit over 'Do Nothing'
Project/Problem:				
Alternative 1	**DG Alt 1 - Existing IC Engines**	$7,932,000	$17,994,618	
Alternative 2	**DG Alt 2 - Microturbines**	$29,844,000	$40,984,453	$22,989,836
Alternative 3	**DG Alt 3 - Centralized Cogen w/ Gas Turbines**	$67,500,000	$49,994,494	$31,999,876
Alternative 4	**DG Alt 4 - RNG for Pipeline Injection**	$20,847,600	$2,418,047	($15,576,571)
Alternative 5	**DG Alt 5 - CNG for Vehicle Fuel**	$19,620,000	$57,917,283	$39,922,665

Year of analysis:	2016
Escalation rate:	3.00%
Discount rate:	2.00%

From Summary Sheet:

Year of analysis	**2016**	**Benefits**	
Escalation rate	**3.00%**	**Capital costs**	
Discount rate	**2.00%**	**Running costs**	

Risk adjustments (+/- percent):

Inland Empire Utilities Agency

Life Cycle Alternative Cost Analysis ($000s)
Alternative 1 - DG Alt 1 - Existing IC Engines

Year 2016–2030

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Expressed in 2016 dollars, unescalated															
Capital Outlays															
DG-Alt-1			793,200	793,200	793,200	1,586,400	1,586,400	2,379,600							
Other															
Other															
Other															
Total capital outlays			**793,200**	**793,200**	**793,200**	**1,586,400**	**1,586,400**	**2,379,600**							
Benefits:															
Power Production from RP-5 biogas								1,285,623	1,304,282	1,322,940	1,369,075	1,415,211	1,461,346	1,507,481	1,553,617
Power Production from RP-5 SHF gas								1,670,877	1,652,218	1,633,560	1,587,425	1,541,289	1,495,154	1,449,019	1,402,883
Heat Recovery (total)								129,830	133,284	136,737	140,191	143,644	147,098	150,552	154,005
Total benefits								**3,086,330**	**3,089,784**	**3,093,237**	**3,096,691**	**3,100,144**	**3,103,598**	**3,107,052**	**3,110,505**
Annual Running Costs:															
Parasitic Load - RP-5 biogas								142,847	144,920	146,993	152,119	157,246	162,372	167,498	172,624
Parasitic Load - RP-5 SHF gas								185,653	183,580	181,507	176,381	171,254	166,128	161,002	155,876
Maintenance								473,040	473,040	473,040	473,040	473,040	473,040	473,040	473,040
Labor															
Other															
Other															
Other															
Other															
Total running costs								**801,540**	**801,540**	**801,540**	**801,540**	**801,540**	**801,540**	**801,540**	**801,540**
R&R Costs:															
R&R - Existing REEP engines - RP-5 SHF Gas								70,000	70,000	70,000	70,000	70,000	70,000	70,000	70,000
Other															
Other															
Other															
Total refurbishments								**70,000**	**70,000**	**70,000**	**70,000**	**70,000**	**70,000**	**70,000**	**70,000**
Net Benefit/(cost)			**(793,200)**	**(793,200)**	**(793,200)**	**(1,586,400)**	**(1,586,400)**	**(164,810)**	**2,218,244**	**2,221,697**	**2,225,151**	**2,228,604**	**2,232,058**	**2,235,512**	**2,238,965**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
DG-Alt-1			841,506	866,751	892,754	1,839,072	1,894,245	2,926,608							
Other															
Other															
Other															
Total capital outlays			**841,506**	**866,751**	**892,754**	**1,839,072**	**1,894,245**	**2,926,608**							
Benefits:															
Power Production from RP-5 biogas								1,581,154	1,652,225	1,726,137	1,839,923	1,958,983	2,083,530	2,213,787	2,349,985
Heat Recovery (total)								159,675	168,840	178,411	188,405	198,838	209,727	221,090	232,947
Total benefits								**1,740,829**	**1,821,065**	**1,904,548**	**2,028,328**	**2,157,820**	**2,293,257**	**2,434,877**	**2,582,931**
Annual Running Costs:															
Parasitic Load - RP-5 biogas								175,684	183,581	191,793	204,436	217,665	231,503	245,976	261,109
Parasitic Load - RP-5 SHF gas								228,330	232,553	236,825	237,041	237,056	236,859	236,437	235,776
Maintenance								581,780	599,233	617,210	635,726	654,798	674,442	694,675	715,515
Labor															
Other															
Other															
Other															
Other															
Total running costs								**985,793**	**1,015,367**	**1,045,828**	**1,077,203**	**1,109,519**	**1,142,804**	**1,177,089**	**1,212,401**
R&R Costs:															
R&R - Existing REEP engines - RP-5 SHF Gas								86,091	88,674	91,334	94,074	96,896	99,803	102,797	105,881
Other															
Other															
Other															
Total refurbishments								**86,091**	**88,674**	**91,334**	**94,074**	**96,896**	**99,803**	**102,797**	**105,881**
Net escalated benefit/(cost)			**(841,506)**	**(866,751)**	**(892,754)**	**(1,839,072)**	**(1,894,245)**	**(2,257,663)**	**717,024**	**767,386**	**857,051**	**951,405**	**1,050,649**	**1,154,992**	**1,264,649**
Life cycle cost analysis															
PVs in 2016			(808,829)	(816,759)	(824,766)	(1,665,705)	(1,682,035)	(1,965,432)	611,973	642,114	703,080	765,180	828,430	892,846	958,446
NPV as of 2016	**17,994,618**														

Year 2031–2045

	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Expressed in 2016 dollars, unescalated															
Capital Outlays															
DG-Alt-1															
Other															
Other															
Other															
Total capital outlays															
Benefits:															
Power Production from RP-5 biogas	1,581,865	1,610,113	1,638,361	1,666,609	1,694,857	1,725,442	1,756,027	1,786,612	1,817,196	1,847,781	1,870,849	1,893,917	1,916,984	1,940,052	1,963,120
Power Production from RP-5 SHF gas	1,374,635	1,346,387	1,318,139	1,289,891	1,261,643	1,231,058	1,200,473	1,169,888	1,139,304	1,108,719	1,085,651	1,062,583	1,039,516	1,016,448	993,380
Heat Recovery (total)	157,459	160,913	164,366	167,820	171,273	174,078	176,883	179,688	182,493	185,298	188,103	190,908	193,713	196,518	199,323
Total benefits	**3,113,959**	**3,117,413**	**3,120,866**	**3,124,320**	**3,127,773**	**3,130,578**	**3,133,383**	**3,136,188**	**3,138,993**	**3,141,798**	**3,144,603**	**3,147,408**	**3,150,213**	**3,153,018**	**3,155,823**
Annual Running Costs:															
Parasitic Load - RP-5 biogas	175,763	178,901	182,040	185,179	188,317	191,716	195,114	198,512	201,911	205,309	207,872	210,435	212,998	215,561	218,124
Parasitic Load - RP-5 SHF gas	152,737	149,599	146,460	143,321	140,183	136,784	133,386	129,988	126,589	123,191	120,628	118,065	115,502	112,939	110,376
Maintenance	473,040	473,040	473,040	473,040	473,040	473,040	473,040	473,040	473,040	473,040	473,040	473,040	473,040	473,040	473,040
Labor															
Other															
Other															
Other															
Other															
Total running costs	**801,540**	**801,540**	**801,540**	**801,540**	**801,540**	**801,540**	**801,540**	**801,540**	**801,540**	**801,540**	**801,540**	**801,540**	**801,540**	**801,540**	**801,540**
R&R Costs:															
R&R - Existing REEP engines - RP-5 SHF Gas	70,000	70,000	70,000	70,000	70,000	70,000	70,000	70,000	70,000	70,000	70,000	70,000	70,000	70,000	70,000
Other															
Other															
Other															
Total refurbishments	**70,000**	**70,000**	**70,000**	**70,000**	**70,000**	**70,000**	**70,000**	**70,000**	**70,000**	**70,000**	**70,000**	**70,000**	**70,000**	**70,000**	**70,000**
Net Benefit/(cost)	**2,242,419**	**2,245,873**	**2,249,326**	**2,252,780**	**2,256,233**	**2,259,038**	**2,261,843**	**2,264,648**	**2,267,453**	**2,270,258**	**2,273,063**	**2,275,868**	**2,278,673**	**2,281,478**	**2,284,283**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
DG-Alt-1															
Other															
Other															
Other															
Total capital outlays															
Benefits:															
Power Production from RP-5 biogas	2,464,494	2,583,758	2,707,961	2,837,290	2,971,941	3,116,339	3,266,727	3,423,332	3,586,394	3,756,159	3,917,143	4,084,404	4,258,176	4,438,699	4,626,220
Heat Recovery (total)	245,316	258,217	271,672	285,702	300,329	314,405	329,055	344,301	360,166	376,673	393,847	411,711	430,293	449,620	469,719
Total benefits	**2,709,809**	**2,841,976**	**2,979,633**	**3,122,992**	**3,272,270**	**3,430,744**	**3,595,782**	**3,767,634**	**3,946,561**	**4,132,833**	**4,310,989**	**4,496,116**	**4,688,470**	**4,888,319**	**5,095,939**
Annual Running Costs:															
Parasitic Load - RP-5 biogas	273,833	287,084	300,885	315,254	330,216	346,260	362,970	380,370	398,488	417,351	435,238	453,823	473,131	493,189	514,024
Parasitic Load - RP-5 SHF gas	237,960	240,062	242,076	243,995	245,811	247,048	248,137	249,070	249,835	250,422	252,568	254,618	256,563	258,395	260,107
Maintenance	736,981	759,090	781,863	805,319	829,479	854,363	879,994	906,394	933,585	961,593	990,441	1,020,154	1,050,759	1,082,281	1,114,750
Labor															
Other															
Other															
Other															
Other															
Total running costs	**1,248,773**	**1,286,236**	**1,324,823**	**1,364,568**	**1,405,505**	**1,447,670**	**1,491,101**	**1,535,834**	**1,581,909**	**1,629,366**	**1,678,247**	**1,728,594**	**1,780,452**	**1,833,866**	**1,888,882**
R&R Costs:															
R&R - Existing REEP engines - RP-5 SHF Gas	109,058	112,329	115,699	119,170	122,745	126,428	130,221	134,127	138,151	142,296	146,564	150,961	155,490	160,155	164,960
Other															
Other															
Other															
Total refurbishments	**109,058**	**112,329**	**115,699**	**119,170**	**122,745**	**126,428**	**130,221**	**134,127**	**138,151**	**142,296**	**146,564**	**150,961**	**155,490**	**160,155**	**164,960**
Net escalated benefit/(cost)	**1,351,979**	**1,443,410**	**1,539,110**	**1,639,253**	**1,744,020**	**1,856,646**	**1,974,461**	**2,097,673**	**2,226,501**	**2,361,171**	**2,486,178**	**2,616,560**	**2,752,528**	**2,894,298**	**3,042,098**
Life cycle cost analysis															
PVs in 2016	1,004,540	1,051,446	1,099,175	1,147,738	1,197,149	1,249,470	1,302,701	1,356,857	1,411,949	1,467,991	1,515,402	1,563,602	1,612,601	1,662,411	1,713,043

Total risk-adjusted capital outlays: $7,932,000

Alternative: 1
Row: 8

Summary!A8	Alternative
Summary!B8	Alt. number
Summary!C8	Alt. name
Summary!E8	Risk premium
Summary!G8	Benefit sens.
Summary!H8	Capital sens
Summary!I8	Running sens.

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2016	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	2.00%	Running costs	

Inland Empire Utilities Agency

Life Cycle Alternative Cost Analysis ($000s)
Alternative 2 - DG Alt 2 - Microturbines

Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Expressed in 2016 dollars, unescalated																														
Capital Outlays																														
DG-Alt-2			2,984,400	2,984,400	2,984,400	5,968,800	5,968,800	8,953,200																						
Other																														
Other																														
Other																														
Other																														
Other																														
Total capital outlays			**2,984,400**	**2,984,400**	**2,984,400**	**5,968,800**	**5,968,800**	**8,953,200**																						
Benefits:																														
Power Production - microturbines								1,042,397	1,057,526	1,072,654	1,110,061	1,147,468	1,184,875	1,222,282	1,259,689	1,282,593	1,305,497	1,328,401	1,351,304	1,374,208	1,399,007	1,423,805	1,448,604	1,473,403	1,498,201	1,516,905	1,535,608	1,554,312	1,573,015	1,591,719
Heat Recovery - total								129,830	133,284	136,737	140,191	143,644	147,098	150,552	154,005	157,459	160,913	164,366	167,820	171,273	174,078	176,883	179,688	182,493	185,298	188,103	190,908	193,713	196,518	199,323
Power Production - (E) IC Engines								2,158,253	2,171,414	2,184,574	2,197,230	2,209,886	2,222,542	2,235,198	2,247,853	2,259,973	2,272,093	2,284,212	2,296,332	2,308,451	2,321,140	2,333,830	2,346,519	2,359,208	2,371,897	2,385,189	2,398,481	2,411,772	2,425,064	2,438,356
Total benefits								**3,330,480**	**3,362,223**	**3,393,966**	**3,447,482**	**3,500,999**	**3,554,515**	**3,608,031**	**3,661,548**	**3,700,025**	**3,738,502**	**3,776,979**	**3,815,456**	**3,853,933**	**3,894,226**	**3,934,518**	**3,974,811**	**4,015,104**	**4,055,396**	**4,090,197**	**4,124,997**	**4,159,798**	**4,194,598**	**4,229,398**
Annual Running Costs:																														
Parasitic Load - microturbines								115,822	117,503	119,184	123,340	127,496	131,653	135,809	139,965	142,510	145,055	147,600	150,145	152,690	155,445	158,201	160,956	163,711	166,467	168,545	170,623	172,701	174,779	176,858
Parasitic Load - (E) IC Engines								239,806	241,268	242,730	244,137	245,543	246,949	248,355	249,761	251,108	252,455	253,801	255,148	256,495	257,904	259,314	260,724	262,134	263,544	265,021	266,498	267,975	269,452	270,928
Maintenance								553,800	558,931	564,063	573,569	583,075	592,582	602,088	611,594	618,114	624,634	631,154	637,674	644,194	651,184	658,174	665,164	672,154	679,144	685,011	690,879	696,746	702,613	708,481
Labor																														
Labor																														
Other																														
Total running costs								**909,428**	**917,702**	**925,977**	**941,046**	**956,115**	**971,184**	**986,252**	**1,001,321**	**1,011,733**	**1,022,144**	**1,032,555**	**1,042,967**	**1,053,378**	**1,064,533**	**1,075,689**	**1,086,844**	**1,097,999**	**1,109,155**	**1,118,577**	**1,128,000**	**1,137,422**	**1,146,844**	**1,156,267**
R&R Costs:																														
General Repair and Replacement								140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000
Other																														
Total RR								**140,000**	**140,000**	**140,000**	**140,000**	**140,000**	**140,000**	**140,000**	**140,000**	**140,000**	**140,000**	**140,000**	**140,000**	**140,000**	**140,000**	**140,000**	**140,000**	**140,000**	**140,000**	**140,000**	**140,000**	**140,000**	**140,000**	**140,000**
Net Benefit/(cost)			**(2,984,400)**	**(2,984,400)**	**(2,984,400)**	**(5,968,800)**	**(5,968,800)**	**(6,672,147)**	**2,304,521**	**2,327,989**	**2,366,436**	**2,404,884**	**2,443,331**	**2,481,779**	**2,520,227**	**2,548,292**	**2,576,358**	**2,604,423**	**2,632,489**	**2,660,555**	**2,689,692**	**2,718,829**	**2,747,967**	**2,777,104**	**2,806,242**	**2,831,620**	**2,856,998**	**2,882,376**	**2,907,754**	**2,933,131**
Expressed in escalated dollars with sensitivity adjustments																														
Capital Outlays																														
DG-Alt-2			3,166,150	3,261,134	3,358,968	6,919,475	7,127,059	11,011,307																						
Other																														
Other																														
Other																														
Other																														
Other																														
Total capital outlays			**3,166,150**	**3,261,134**	**3,358,968**	**6,919,475**	**7,127,059**	**11,011,307**																						
Benefits:																														
Power Production - microturbines								1,282,017	1,339,642	1,399,570	1,491,829	1,588,364	1,689,349	1,794,963	1,905,393	1,998,238	2,094,939	2,195,644	2,300,505	2,409,682	2,526,762	2,648,697	2,775,675	2,907,887	3,045,535	3,176,062	3,311,679	3,452,575	3,598,945	3,750,989
Heat Recovery - total								159,675	168,840	178,411	188,405	198,838	209,727	221,090	232,947	245,316	258,217	271,672	285,702	300,329	314,405	329,055	344,301	360,166	376,673	393,847	411,711	430,293	449,620	469,719
Power Production - (E) IC Engines								2,654,379	2,750,682	2,850,374	2,952,893	3,058,999	3,168,813	3,282,463	3,400,080	3,520,964	3,646,042	3,775,455	3,909,351	4,047,883	4,192,238	4,341,610	4,496,172	4,656,101	4,821,578	4,994,056	5,172,542	5,357,244	5,548,372	5,746,146
Total benefits								**4,096,071**	**4,259,163**	**4,428,355**	**4,633,128**	**4,846,201**	**5,067,888**	**5,298,516**	**5,538,420**	**5,764,518**	**5,999,198**	**6,242,771**	**6,495,558**	**6,757,894**	**7,033,404**	**7,319,363**	**7,616,149**	**7,924,155**	**8,243,786**	**8,563,964**	**8,895,933**	**9,240,113**	**9,596,937**	**9,966,854**
Annual Running Costs:																														
Parasitic Load - microturbines								142,446	148,849	155,508	165,759	176,485	187,705	199,440	211,710	222,026	232,771	243,960	255,612	267,742	280,751	294,300	308,408	323,099	338,393	352,896	367,964	383,619	399,883	416,777
Parasitic Load - (E) IC Engines								294,931	305,631	316,708	328,099	339,889	352,090	364,718	377,787	391,218	405,116	419,495	434,372	449,765	465,804	482,401	499,575	517,345	535,731	554,895	574,727	595,249	616,486	638,461
Maintenance								681,104	708,037	735,974	770,829	807,113	844,880	884,187	925,091	963,002	1,002,354	1,043,201	1,085,597	1,129,598	1,176,110	1,224,397	1,274,523	1,326,554	1,380,559	1,434,261	1,489,943	1,547,674	1,607,528	1,669,581
Labor																														
Labor																														
Other																														
Total running costs								**1,118,481**	**1,162,518**	**1,208,190**	**1,264,687**	**1,323,486**	**1,384,676**	**1,448,345**	**1,514,588**	**1,576,247**	**1,640,241**	**1,706,657**	**1,775,581**	**1,847,105**	**1,922,666**	**2,001,098**	**2,082,506**	**2,166,997**	**2,254,683**	**2,342,052**	**2,432,634**	**2,526,543**	**2,623,897**	**2,724,819**
R&R Costs:																														
General Repair and Replacement								172,182	177,348	182,668	188,148	193,793	199,607	205,595	211,763	218,115	224,659	231,399	238,341	245,491	252,856	260,441	268,254	276,302	284,591	293,129	301,923	310,980	320,310	329,919
Other																														
Total RR								**172,182**	**177,348**	**182,668**	**188,148**	**193,793**	**199,607**	**205,595**	**211,763**	**218,115**	**224,659**	**231,399**	**238,341**	**245,491**	**252,856**	**260,441**	**268,254**	**276,302**	**284,591**	**293,129**	**301,923**	**310,980**	**320,310**	**329,919**
Net escalated benefit/(cost)			**(3,166,150)**	**(3,261,134)**	**(3,358,968)**	**(6,919,475)**	**(7,127,059)**	**(8,205,900)**	**2,919,298**	**3,037,497**	**3,180,292**	**3,328,922**	**3,483,606**	**3,644,576**	**3,812,069**	**3,970,156**	**4,134,298**	**4,304,715**	**4,481,636**	**4,665,299**	**4,857,883**	**5,057,824**	**5,265,389**	**5,480,856**	**5,704,512**	**5,928,783**	**6,161,376**	**6,402,589**	**6,652,730**	**6,912,116**
Life cycle cost analysis																														
PVs in 2016			(3,043,204)	(3,073,040)	(3,103,168)	(6,267,182)	(6,328,625)	(7,143,730)	2,491,592	2,541,642	2,608,947	2,677,329	2,746,800	2,817,376	2,889,072	2,949,885	3,011,612	3,074,266	3,137,860	3,202,404	3,269,216	3,337,030	3,405,859	3,475,717	3,546,618	3,613,776	3,681,911	3,751,034	3,821,159	3,892,298
NPV as of 2016	**40,984,453**																													

Total risk-adjusted capital outlays: $29,844,000

Alternative: 2
Row: 9

Summary!A9	Alternative
Summary!B9	Alt. number
Summary!C9	Alt. name
Summary!E9	Risk premium
Summary!G9	Benefit sens.
Summary!H9	Capital sens.
Summary!I9	Running sens.

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2016	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	2.00%	Running costs	

Inland Empire Utilities Agency

Life Cycle Alternative Cost Analysis ($000s)

Alternative 3 - DG Alt 3 - Centralized Cogen w/ Gas Turbines

Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Expressed in 2016 dollars, unescalated															
Capital Outlays															
Centralized Cogen			6,750,000	6,750,000	13,500,000	13,500,000	13,500,000	13,500,000							
Other															
Other															
Other															
Total capital outlays			**6,750,000**	**6,750,000**	**13,500,000**	**13,500,000**	**13,500,000**	**13,500,000**							
Benefits:															
Power Production - Gas Turbines								3,556,294	3,608,001	3,659,708	3,739,635	3,819,561	3,899,487	3,979,414	4,059,340
Heat Generation - Total								129,830	133,284	136,737	140,191	143,644	147,098	150,552	154,005
Power Production - (E) IC Engines								2,158,253	2,171,414	2,184,574	2,197,230	2,209,886	2,222,542	2,235,198	2,247,853
Total benefits								**5,844,378**	**5,912,699**	**5,981,020**	**6,077,056**	**6,173,091**	**6,269,127**	**6,365,163**	**6,461,199**
Annual Running Costs:															
Parasitic Load - Gas Turbines								395,144	400,889	406,634	415,515	424,396	433,276	442,157	451,038
Parasitic Load - (E) IC Engines								239,806	241,268	242,730	244,137	245,543	246,949	248,355	249,761
Maintenance								1,198,831	1,213,347	1,227,862	1,249,069	1,270,276	1,291,484	1,312,691	1,333,898
Labor															
Other															
Other															
Total running costs								**1,833,781**	**1,855,504**	**1,877,227**	**1,908,721**	**1,940,215**	**1,971,709**	**2,003,203**	**2,034,697**
R&R Costs:															
R&R								215,000	215,000	215,000	215,000	215,000	215,000	215,000	215,000
Other															
Other															
Other															
Total refurbishments								**215,000**	**215,000**	**215,000**	**215,000**	**215,000**	**215,000**	**215,000**	**215,000**
Net Benefit/(cost)			**(6,750,000)**	**(6,750,000)**	**#########**	**#########**	**#########**	**(9,704,403)**	**3,842,195**	**3,888,793**	**3,953,335**	**4,017,876**	**4,082,418**	**4,146,960**	**4,211,501**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Centralized Cogen			7,161,075	7,375,907	15,194,369	15,650,200	16,119,706	16,603,297							
Other															
Other															
Other															
Total capital outlays			**7,161,075**	**7,375,907**	**15,194,369**	**15,650,200**	**16,119,706**	**16,603,297**							
Benefits:															
Power Production - Gas Turbines								4,373,794	4,570,508	4,775,089	5,025,756	5,287,166	5,559,736	5,843,903	6,140,116
Heat Generation - Total								159,675	168,840	178,411	188,405	198,838	209,727	221,090	232,947
Power Production - (E) IC Engines								2,654,379	2,750,682	2,850,374	2,952,893	3,058,999	3,168,813	3,282,463	3,400,080
Total benefits								**7,187,847**	**7,490,030**	**7,803,874**	**8,167,055**	**8,545,002**	**8,938,276**	**9,347,456**	**9,773,143**
Annual Running Costs:															
Parasitic Load - Gas Turbines								485,977	507,834	530,565	558,417	587,463	617,748	649,323	682,235
Parasitic Load - (E) IC Engines								294,931	305,631	316,708	328,099	339,889	352,090	364,718	377,787
Maintenance								1,474,411	1,537,031	1,602,081	1,678,644	1,758,360	1,841,347	1,927,731	2,017,641
Labor															
Other															
Other															
Total running costs								**2,255,319**	**2,350,497**	**2,449,355**	**2,565,161**	**2,685,711**	**2,811,186**	**2,941,771**	**3,077,662**
R&R Costs:															
R&R								264,423	272,356	280,526	288,942	297,610	306,539	315,735	325,207
Other															
Other															
Other															
Total refurbishments								**264,423**	**272,356**	**280,526**	**288,942**	**297,610**	**306,539**	**315,735**	**325,207**
Net escalated benefit/(cost)			**(7,161,075)**	**(7,375,907)**	**#########**	**#########**	**#########**	**#########**	**4,867,178**	**5,073,993**	**5,312,951**	**5,561,681**	**5,820,552**	**6,089,950**	**6,370,274**
Life cycle cost analysis															
PVs in 2016			(6,883,002)	(6,950,482)	#########	#########	#########	#########	4,154,089	4,245,690	4,358,471	4,473,054	4,589,465	4,707,729	4,827,871
NPV as of 2016	**49,994,494**														

Year	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Expressed in 2016 dollars, unescalated															
Capital Outlays															
Centralized Cogen															
Other															
Other															
Other															
Total capital outlays															
Benefits:															
Power Production - Gas Turbines	4,174,378	4,289,416	4,404,453	4,519,491	4,533,300	4,533,300	4,533,300	4,533,300	4,533,300	4,533,300	4,533,300	4,533,300	4,533,300	4,533,300	4,533,300
Heat Generation - Total	157,459	160,913	164,366	167,820	171,273	174,078	176,883	179,688	182,493	185,298	188,103	190,908	193,713	196,518	199,323
Power Production - (E) IC Engines	2,259,973	2,272,093	2,284,212	2,296,332	2,308,451	2,321,140	2,333,830	2,346,519	2,359,208	2,371,897	2,385,189	2,398,481	2,411,772	2,425,064	2,438,356
Total benefits	**6,591,810**	**6,722,421**	**6,853,032**	**6,983,643**	**7,013,025**	**7,028,519**	**7,044,013**	**7,059,507**	**7,075,001**	**7,090,495**	**7,106,592**	**7,122,689**	**7,138,786**	**7,154,883**	**7,170,980**
Annual Running Costs:															
Parasitic Load - Gas Turbines	463,820	476,602	489,384	502,166	503,700	503,700	503,700	503,700	503,700	503,700	503,700	503,700	503,700	503,700	503,700
Parasitic Load - (E) IC Engines	251,108	252,455	253,801	255,148	256,495	257,904	259,314	260,724	262,134	263,544	265,021	266,498	267,975	269,452	270,928
Maintenance	1,363,446	1,392,995	1,422,543	1,452,091	1,457,344	1,459,374	1,461,405	1,463,435	1,465,465	1,467,496	1,469,622	1,471,749	1,473,876	1,476,002	1,478,129
Labor															
Other															
Other															
Total running costs	**2,078,374**	**2,122,051**	**2,165,728**	**2,209,405**	**2,217,539**	**2,220,979**	**2,224,419**	**2,227,859**	**2,231,299**	**2,234,740**	**2,238,343**	**2,241,947**	**2,245,550**	**2,249,154**	**2,252,757**
R&R Costs:															
R&R	215,000	215,000	215,000	215,000	215,000	215,000	215,000	215,000	215,000	215,000	215,000	215,000	215,000	215,000	215,000
Other															
Other															
Other															
Total refurbishments	**215,000**	**215,000**	**215,000**	**215,000**	**215,000**	**215,000**	**215,000**	**215,000**	**215,000**	**215,000**	**215,000**	**215,000**	**215,000**	**215,000**	**215,000**
Net Benefit/(cost)	**4,298,435**	**4,385,370**	**4,472,304**	**4,559,238**	**4,580,486**	**4,592,540**	**4,604,594**	**4,616,648**	**4,628,702**	**4,640,756**	**4,653,249**	**4,665,742**	**4,678,236**	**4,690,729**	**4,703,222**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Centralized Cogen															
Other															
Other															
Other															
Total capital outlays															
Benefits:															
Power Production - Gas Turbines	6,503,544	6,883,253	7,279,890	7,694,131	7,949,169	8,187,644	8,433,273	8,686,272	8,946,860	9,215,266	9,491,723	9,776,475	10,069,769	10,371,863	10,683,018
Heat Generation - Total	245,316	258,217	271,672	285,702	300,329	314,405	329,055	344,301	360,166	376,673	393,847	411,711	430,293	449,620	469,719
Power Production - (E) IC Engines	3,520,964	3,646,042	3,775,455	3,909,351	4,047,883	4,192,238	4,341,610	4,496,172	4,656,101	4,821,578	4,994,056	5,172,542	5,357,244	5,548,372	5,746,146
Total benefits	**10,269,825**	**10,787,512**	**11,327,017**	**11,889,184**	**12,297,381**	**12,694,287**	**13,103,939**	**13,526,746**	**13,963,127**	**14,413,517**	**14,879,626**	**15,360,729**	**15,857,307**	**16,369,854**	**16,898,883**
Annual Running Costs:															
Parasitic Load - Gas Turbines	722,616	764,806	808,877	854,903	883,241	909,738	937,030	965,141	994,096	1,023,918	1,054,636	1,086,275	1,118,863	1,152,429	1,187,002
Parasitic Load - (E) IC Engines	391,218	405,116	419,495	434,372	449,765	465,804	482,401	499,575	517,345	535,731	554,895	574,727	595,249	616,486	638,461
Maintenance	2,124,205	2,235,347	2,351,246	2,472,088	2,555,462	2,635,793	2,718,643	2,804,093	2,892,222	2,983,116	3,077,063	3,173,961	3,273,904	3,376,987	3,483,308
Labor															
Other															
Other															
Total running costs	**3,238,039**	**3,405,269**	**3,579,618**	**3,761,363**	**3,888,468**	**4,011,335**	**4,138,075**	**4,268,809**	**4,403,662**	**4,542,766**	**4,686,594**	**4,834,963**	**4,988,016**	**5,145,901**	**5,308,771**
R&R Costs:															
R&R	334,963	345,012	355,362	366,023	377,004	388,314	399,963	411,962	424,321	437,051	450,162	463,667	477,577	491,904	506,662
Other															
Other															
Other															
Total refurbishments	**334,963**	**345,012**	**355,362**	**366,023**	**377,004**	**388,314**	**399,963**	**411,962**	**424,321**	**437,051**	**450,162**	**463,667**	**477,577**	**491,904**	**506,662**
Net escalated benefit/(cost)	**6,696,822**	**7,037,231**	**7,392,037**	**7,761,798**	**8,031,910**	**8,294,638**	**8,565,901**	**8,845,975**	**9,135,143**	**9,433,701**	**9,742,870**	**10,062,099**	**10,391,713**	**10,732,048**	**11,083,451**
Life cycle cost analysis															
PVs in 2016	4,975,838	5,126,241	5,279,116	5,434,495	5,513,350	5,582,053	5,651,574	5,721,922	5,793,105	5,865,135	5,938,580	6,012,902	6,088,110	6,164,215	6,241,228

Inland Empire Utilities Agency

Life Cycle Alternative Cost Analysis ($000s)
Alternative 4 - DG Alt 4 - RNG for Pipeline Injection

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2016	Benefits	
Escalation rate	3.00%	Capital costs	
Discount rate	2.00%	Running costs	

20,847,600

Year

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Expressed in 2016 dollars, unescalated															
Capital Outlays															
RNG System			2,084,760	2,084,760	4,169,520	4,169,520	4,169,520	4,169,520							
Other															
Other															
Other															
Total capital outlays			2.084.760	2.084.760	4.169.520	4.169.520	4.169.520	4.169.520							
Benefits:															
RNG Sales								441,775	448,187	454,598	470,452	486,305	502,158	518,012	533,865
RNG LCFS Credits								390,087	395,749	401,410	415,409	429,407	443,406	457,404	471,403
RNG RIN Credits								515,404	522,884	530,365	548,860	567,356	585,851	604,347	622,842
Power production - (E) IC Engines								2,158,253	2,171,414	2,184,574	2,197,230	2,209,886	2,222,542	2,235,198	2,247,853
Total benefits								3.505.520	3.538.234	3.570.947	3.631.951	3.692.954	3.753.957	3.814.960	3.875.964
Annual Running Costs:															
RNG Maintenance								200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000
Parasitic Loads - IC Engines								239,806	241,268	242,730	244,137	245,543	246,949	248,355	249,761
Maintenance - IC Engines								345,321	347,426	349,532	351,557	353,582	355,607	357,632	359,657
Other															
Total running costs								785.126	788.694	792.262	795.693	799.125	802.556	805.987	809.418
R&R Costs:															
R&R								34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000
Other															
Total refurbishments								34.000	34.000	34.000	34.000	34.000	34.000	34.000	34.000
Net Benefit/(cost)			(2.084.760)	(2.084.760)	(4.169.520)	(4.169.520)	(4.169.520)	(1.483.127)	2.715.539	2.744.685	2.802.257	2.859.829	2.917.401	2.974.973	3.032.546
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
RNG System			2,211,722	2,278,074	4,692,831	4,833,616	4,978,625	5,127,984							
Other															
Other															
Other															
Total capital outlays			2.211.722	2.278.074	4.692.831	4.833.616	4.978.625	5.127.984							
Benefits:															
RNG Sales								543,328	567,749	593,148	632,248	673,160	715,958	760,718	807,519
RNG LCFS Credits								479,758	501,323	523,749	558,275	594,400	632,191	671,714	713,039
RNG RIN Credits								633,882	662,374	692,006	737,622	785,353	835,284	887,504	942,105
Total benefits								1.656.968	1.731.447	1.808.902	1.928.144	2.052.913	2.183.432	2.319.935	2.462.663
Annual Running Costs:															
RNG Maintenance								245,975	253,354	260,955	268,783	276,847	285,152	293,707	302,518
Parasitic Loads - IC Engines								294,931	305,631	316,708	328,099	339,889	352,090	364,718	377,787
Maintenance - IC Engines								424,701	440,109	456,060	472,463	489,440	507,010	525,194	544,013
Other															
Total running costs								965.606	999.094	1.033.723	1.069.345	1.106.175	1.144.253	1.183.619	1.224.317
R&R Costs:															
R&R								41,816	43,070	44,362	45,693	47,064	48,476	49,930	51,428
Other															
Total refurbishments								41.816	43.070	44.362	45.693	47.064	48.476	49.930	51.428
Net escalated benefit/(cost)			(2.211.722)	(2.278.074)	(4.692.831)	(4.833.616)	(4.978.625)	(4.478.438)	689.282	730.818	813.106	899.674	990.704	1.086.386	1.186.917
Life cycle cost analysis															
PVs in 2016			(2,125,838)	(2,146,680)	(4,335,451)	(4,377,955)	(4,420,876)	(3,898,750)	588,296	611,515	667,030	723,574	781,163	839,812	899,535
NPV as of 2016	2.418.047														

	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Expressed in 2016 dollars, unescalated															
Capital Outlays															
RNG System															
Other															
Other															
Other															
Total capital outlays															
Benefits:															
RNG Sales	543,572	553,279	562,985	572,692	582,399	592,909	603,419	613,928	624,438	634,948	642,875	650,801	658,728	666,655	674,581
RNG LCFS Credits	479,974	488,545	497,116	505,687	514,258	523,538	532,819	542,099	551,379	560,659	567,658	574,658	581,657	588,656	595,655
RNG RIN Credits	634,167	645,492	656,816	668,141	679,465	691,727	703,988	716,250	728,511	740,773	750,020	759,268	768,516	777,764	787,012
Power production - (E) IC Engines	2,259,973	2,272,093	2,284,212	2,296,332	2,308,451	2,321,140	2,333,830	2,346,519	2,359,208	2,371,897	2,385,189	2,398,481	2,411,772	2,425,064	2,438,356
Total benefits	3.917.686	3.959.408	4.001.130	4.042.852	4.084.574	4.129.314	4.174.055	4.218.795	4.263.536	4.308.277	4.345.742	4.383.208	4.420.673	4.458.139	4.495.604
Annual Running Costs:															
RNG Maintenance	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000
Parasitic Loads - IC Engines	251,108	252,455	253,801	255,148	256,495	257,904	259,314	260,724	262,134	263,544	265,021	266,498	267,975	269,452	270,928
Maintenance - IC Engines	361,596	363,535	365,474	367,413	369,352	371,382	373,413	375,443	377,473	379,504	381,630	383,757	385,884	388,010	390,137
Other															
Total running costs	812.704	815.990	819.275	822.561	825.847	829.287	832.727	836.167	839.607	843.048	846.651	850.255	853.858	857.462	861.065
R&R Costs:															
R&R	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000
Other															
Total refurbishments	34.000	34.000	34.000	34.000	34.000	34.000	34.000	34.000	34.000	34.000	34.000	34.000	34.000	34.000	34.000
Net Benefit/(cost)	3.070.982	3.109.418	3.147.854	3.186.291	3.224.727	3.266.027	3.307.328	3.348.628	3.389.929	3.431.229	3.465.091	3.498.953	3.532.815	3.566.677	3.600.539
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
RNG System															
Other															
Other															
Other															
Total capital outlays															
Benefits:															
RNG Sales	846,867	887,850	930,529	974,970	1,021,240	1,070,859	1,122,536	1,176,350	1,232,383	1,290,719	1,346,037	1,403,512	1,463,225	1,525,258	1,589,695
RNG LCFS Credits	747,784	783,971	821,657	860,898	901,755	945,569	991,199	1,038,717	1,088,194	1,139,704	1,188,550	1,239,302	1,292,028	1,346,803	1,403,701
RNG RIN Credits	988,012	1,035,825	1,085,617	1,137,465	1,191,447	1,249,336	1,309,626	1,372,409	1,437,780	1,505,838	1,570,376	1,637,431	1,707,096	1,779,467	1,854,644
Total benefits	2.582.662	2.707.645	2.837.803	2.973.333	3.114.441	3.265.763	3.423.361	3.587.476	3.758.357	3.936.261	4.104.964	4.280.245	4.462.349	4.651.528	4.848.040
Annual Running Costs:															
RNG Maintenance	311,593	320,941	330,570	340,487	350,701	361,222	372,059	383,221	394,717	406,559	418,756	431,318	444,258	457,586	471,313
Parasitic Loads - IC Engines	391,218	405,116	419,495	434,372	449,765	465,804	482,401	499,575	517,345	535,731	554,895	574,727	595,249	616,486	638,461
Maintenance - IC Engines	563,354	583,367	604,073	625,496	647,661	670,758	694,658	719,388	744,976	771,452	799,049	827,607	857,159	887,739	919,383
Other															
Total running costs	1.266.166	1.309.424	1.354.137	1.400.355	1.448.127	1.497.785	1.549.118	1.602.183	1.657.038	1.713.742	1.772.700	1.833.652	1.896.666	1.961.811	2.029.157
R&R Costs:															
R&R	52,971	54,560	56,197	57,883	59,619	61,408	63,250	65,148	67,102	69,115	71,188	73,324	75,524	77,790	80,123
Other															
Total refurbishments	52.971	54.560	56.197	57.883	59.619	61.408	63.250	65.148	67.102	69.115	71.188	73.324	75.524	77.790	80.123
Net escalated benefit/(cost)	1.263.525	1.343.662	1.427.469	1.515.095	1.606.695	1.706.571	1.810.993	1.920.145	2.034.217	2.153.404	2.261.076	2.373.269	2.490.159	2.611.927	2.738.760
Life cycle cost analysis															
PVs in 2016	938,818	978,785	1,019,445	1,060,808	1,102,885	1,148,473	1,194,850	1,242,025	1,290,011	1,338,818	1,378,195	1,418,216	1,458,890	1,500,225	1,542,229

From Summary Sheet:

Year of analysis	**2016**		**Benefits**	
Escalation rate	**3.00%**		**Capital costs**	
Discount rate	**2.00%**		**Running costs**	

Risk adjustments (+/- percent):

Inland Empire Utilities Agency

Life Cycle Alternative Cost Analysis ($000s)
Alternative 5 - DG Alt 5 - CNG for Vehicle Fuel

Year

	2016	2017	2018	2019	2020	2021	2022	2023
Expressed in 2016 dollars, unescalated								
Capital Outlays								
CNG System			1,962,000	1,962,000	3,924,000	3,924,000	3,924,000	3,924,000
Other								
Other								
Other								
Other								
Other								
Total capital outlays			1.962.000	1.962.000	3.924.000	3.924.000	3.924.000	3.924.000
Benefits:								
CNG Sales								1,162,566
CNG LCFS Credits								780,175
CNG RIN Credits								1,030,809
Power production - (E) IC Engines								2,158,253
Total benefits								5.131.802
Annual Running Costs:								
CNG Maintenance								300,000
Parasitic Loads - IC Engines								239,806
Maintenance - IC Engines								345,321
Other								
Other								
Other								
Other								
Total running costs								885.126
R&R Costs:								
R&R								64,000
Other								
Other								
Other								
Other								
Total refurbishments								64.000
Net Benefit/(cost)			(1.962.000)	(1.962.000)	(3.924.000)	(3.924.000)	(3.924.000)	258.676
Expressed in escalated dollars with sensitivity adjustments								
Capital Outlays								
CNG System			2,081,486	2,143,930	4,416,497	4,548,991	4,685,461	4,826,025
Other								
Other								
Other								
Other								
Other								
Total capital outlays			2.081.486	2.143.930	4.416.497	4.548.991	4.685.461	4.826.025
Benefits:								
CNG Sales								1,429,810
CNG LCFS Credits								959,517
CNG RIN Credits								1,267,764
Total benefits								3.657.091
Annual Running Costs:								
CNG Maintenance								368,962
Parasitic Loads - IC Engines								294,931
Maintenance - IC Engines								424,701
Other								
Other								
Other								
Other								
Total running costs								1.088.594
R&R Costs:								
R&R								78,712
Other								
Other								
Other								
Other								
Total refurbishments								78.712
Net escalated benefit/(cost)			(2.081.486)	(2.143.930)	(4.416.497)	(4.548.991)	(4.685.461)	(2.336.240)
Life cycle cost analysis								
PVs in 2016			(2,000,659)	(2,020,273)	(4,080,160)	(4,120,162)	(4,160,555)	(2,033,838)
NPV as of 2016	57.917.283							

	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Expressed in 2016 dollars, unescalated											
CNG Sales	1,179,439	1,196,311	1,238,030	1,279,750	1,321,469	1,363,188	1,404,908	1,430,452	1,455,996	1,481,540	1,507,084
CNG LCFS Credits	791,498	802,820	830,817	858,815	886,812	914,809	942,806	959,948	977,090	994,232	1,011,374
CNG RIN Credits	1,045,769	1,060,729	1,097,720	1,134,711	1,171,703	1,208,694	1,245,685	1,268,334	1,290,983	1,313,632	1,336,282
Power production - (E) IC Engines	2,171,414	2,184,574	2,197,230	2,209,886	2,222,542	2,235,198	2,247,853	2,259,973	2,272,093	2,284,212	2,296,332
Total benefits	5.188.119	5.244.435	5.363.798	5.483.162	5.602.525	5.721.888	5.841.252	5.918.707	5.996.162	6.073.617	6.151.072
CNG Maintenance	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
Parasitic Loads - IC Engines	241,268	242,730	244,137	245,543	246,949	248,355	249,761	251,108	252,455	253,801	255,148
Maintenance - IC Engines	347,426	349,532	351,557	353,582	355,607	357,632	359,657	361,596	363,535	365,474	367,413
Total running costs	888.694	892.262	895.693	899.125	902.556	905.987	909.418	912.704	915.990	919.275	922.561
R&R	64,000	64,000	64,000	64,000	64,000	64,000	64,000	64,000	64,000	64,000	64,000
Total refurbishments	64.000	64.000	64.000	64.000	64.000	64.000	64.000	64.000	64.000	64.000	64.000
Net Benefit/(cost)	4.235.424	4.288.173	4.404.105	4.520.037	4.635.969	4.751.901	4.867.834	4.942.003	5.016.172	5.090.342	5.164.511
Expressed in escalated dollars with sensitivity adjustments											
CNG Sales	1,494,077	1,560,915	1,663,809	1,771,473	1,884,099	2,001,888	2,125,049	2,228,598	2,336,446	2,448,760	2,565,710
CNG LCFS Credits	1,002,646	1,047,499	1,116,549	1,188,800	1,264,381	1,343,427	1,426,078	1,495,567	1,567,942	1,643,314	1,721,797
CNG RIN Credits	1,324,749	1,384,011	1,475,244	1,570,706	1,670,568	1,775,008	1,884,210	1,976,023	2,071,649	2,171,234	2,274,930
Total benefits	3.821.472	3.992.424	4.255.603	4.530.979	4.819.048	5.120.323	5.435.337	5.700.188	5.976.038	6.263.309	6.562.437
CNG Maintenance	380,031	391,432	403,175	415,270	427,728	440,560	453,777	467,390	481,412	495,854	510,730
Parasitic Loads - IC Engines	305,631	316,708	328,099	339,889	352,090	364,718	377,787	391,218	405,116	419,495	434,372
Maintenance - IC Engines	440,109	456,060	472,463	489,440	507,010	525,194	544,013	563,354	583,367	604,073	625,496
Total running costs	1.125.771	1.164.200	1.203.737	1.244.599	1.286.829	1.330.472	1.375.576	1.421.963	1.469.894	1.519.422	1.570.598
R&R	81,073	83,505	86,011	88,591	91,249	93,986	96,806	99,710	102,701	105,782	108,956
Total refurbishments	81.073	83.505	86.011	88.591	91.249	93.986	96.806	99.710	102.701	105.782	108.956
Net escalated benefit/(cost)	2.614.627	2.744.719	2.965.855	3.197.790	3.440.971	3.695.864	3.962.955	4.178.515	4.403.442	4.638.104	4.882.883
PVs in 2016	2,231,559	2,296,658	2,433,034	2,571,864	2,713,182	2,857,023	3,003,425	3,104,698	3,207,669	3,312,360	3,418,796

	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Expressed in 2016 dollars, unescalated											
CNG Sales	1,532,629	1,560,286	1,587,943	1,615,601	1,643,258	1,670,916	1,691,775	1,712,635	1,733,495	1,754,354	1,775,214
CNG LCFS Credits	1,028,516	1,047,077	1,065,637	1,084,197	1,102,758	1,121,318	1,135,317	1,149,315	1,163,314	1,177,312	1,191,311
CNG RIN Credits	1,358,931	1,383,454	1,407,977	1,432,499	1,457,022	1,481,545	1,500,041	1,518,536	1,537,032	1,555,528	1,574,023
Power production - (E) IC Engines	2,308,451	2,321,140	2,333,830	2,346,519	2,359,208	2,371,897	2,385,189	2,398,481	2,411,772	2,425,064	2,438,356
Total benefits	6.228.527	6.311.957	6.395.387	6.478.817	6.562.246	6.645.676	6.712.322	6.778.967	6.845.613	6.912.259	6.978.904
CNG Maintenance	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
Parasitic Loads - IC Engines	256,495	257,904	259,314	260,724	262,134	263,544	265,021	266,498	267,975	269,452	270,928
Maintenance - IC Engines	369,352	371,382	373,413	375,443	377,473	379,504	381,630	383,757	385,884	388,010	390,137
Total running costs	925.847	929.287	932.727	936.167	939.607	943.048	946.651	950.255	953.858	957.462	961.065
R&R	64,000	64,000	64,000	64,000	64,000	64,000	64,000	64,000	64,000	64,000	64,000
Total refurbishments	64.000	64.000	64.000	64.000	64.000	64.000	64.000	64.000	64.000	64.000	64.000
Net Benefit/(cost)	5.238.680	5.318.670	5.398.660	5.478.649	5.558.639	5.638.629	5.701.671	5.764.713	5.827.755	5.890.797	5.953.839
Expressed in escalated dollars with sensitivity adjustments											
CNG Sales	2,687,474	2,818,050	2,954,043	3,095,658	3,243,112	3,396,628	3,542,202	3,693,454	3,850,593	4,013,836	4,183,408
CNG LCFS Credits	1,803,510	1,891,137	1,982,399	2,077,434	2,176,388	2,279,409	2,377,101	2,478,603	2,584,056	2,693,605	2,807,402
CNG RIN Credits	2,382,893	2,498,671	2,619,251	2,744,817	2,875,560	3,011,677	3,140,752	3,274,862	3,414,192	3,558,935	3,709,289
Total benefits	6.873.876	7.207.858	7.555.693	7.917.910	8.295.060	8.687.713	9.060.056	9.446.919	9.848.841	10.266.376	10.700.099
CNG Maintenance	526,052	541,833	558,088	574,831	592,076	609,838	628,133	646,977	666,387	686,378	706,970
Parasitic Loads - IC Engines	449,765	465,804	482,401	499,575	517,345	535,731	554,895	574,727	595,249	616,486	638,461
Maintenance - IC Engines	647,661	670,758	694,658	719,388	744,976	771,452	799,049	827,607	857,159	887,739	919,383
Total running costs	1.623.478	1.678.396	1.735.147	1.793.793	1.854.397	1.917.022	1.982.077	2.049.311	2.118.795	2.190.604	2.264.814
R&R	112,224	115,591	119,059	122,631	126,310	130,099	134,002	138,022	142,162	146,427	150,820
Total refurbishments	112.224	115.591	119.059	122.631	126.310	130.099	134.002	138.022	142.162	146.427	150.820
Net escalated benefit/(cost)	5.138.174	5.413.872	5.701.487	6.001.486	6.314.354	6.640.593	6.943.976	7.259.586	7.587.884	7.929.345	8.284.465
PVs in 2016	3,527,001	3,643,380	3,761,703	3,881,995	4,004,285	4,128,599	4,232,568	4,338,178	4,445,453	4,554,414	4,665,084

Digester Gas Utilization Alternatives

	Alt. 1: Expand REEP Capacity		Alt. 2: Existing REEP + New Cogeneration System		Alt. 3A: Centralized Cogeneration System		Alt. 4: Utilize DG for Pipeline Injection (RNG)		Alt. 5: Compressed Natural Gas for Vehicle Fuel (CNG)		Notes
System Components	**System Size**	**Cost**	**System Size**	**Cost**	**System Size**	**Cost**	**System Size**	**Cost**	**System Size**	**Cost**	
Capital Costs (for 2060 facilities)											
IC Engines			-	-	-	-	-	-	-	-	$2000/kW
Microturbines	-	-	7 @ 250 kW each	10,329,000	-	-	-	-	-	-	
Gas Turbines	-	-	-	-	1 @ 4.6 MW	12,912,000	-	-	-	-	
Selective Catalytic Converter		1,002,000		1,002,000		1,002,000		1,002,000		1,002,000	
Basic Gas Conditioning @ RP-5	460 scfm (2035 quantity)	1,845,000	570 scfm	1,845,000	570 scfm	1,845,000	570 scfm	1,845,000	570 scfm	1,845,000	
Basic Gas Conditioning @ RP-1	-	-	-	-	800 scfm	2,767,000	-	-	-	-	
Microturbines Compression Stn	-	-	570 scfm	738,000	-	-	-	-	-	-	
Gas Turbines Compression Stn	-	-	-	-	1400 scfm, 250 psi	1,845,000	-	-	-	-	
Digester Gas Pipeline	-	-	-	-	8 miles, 12 inches	12,100,000	-	-	-	-	$200/ft
CO_2 Removal System	-	-	-	-	-	-	570 scfm	2,213,000	570 scfm	2,213,000	
RP-1 Compression Station	-	-	-	-	800 scfm, 10 psi	461,000	-	-	-	-	
High Pressure Compression	-	-	-	-	-	-	-	-	340 scfm, 4000 psi	1,845,000	
Low Pressure Compression	-	-	-	-	-	-	340 scfm, 100 psi	922,000	-	-	
Pipeline Injection Point of Receipt	-	-	-	-	-	-	340 scfm	2,420,000	-	-	
CNG Filling Station/storage	-	-	-	-	-	-	-	-	340 scfm, 4000 psi	1,845,000	
RNG Pipeline Extension							1 mile - RNG pipe extension	968,000			$150/ft
Existing REEP Heat Recovery System Modifications		505,000		505,000		505,000		505,000		505,000	
SHF Gas Conditioning		654,000		654,000		654,000		654,000		654,000	
Base Cost		4,006,000		$15,073,000		$34,091,000		$10,529,000		$9,909,000	
Overhead & Profit, Inflation, Bonds & Insurances, Contingency		$2,604,000		$9,797,000		$22,159,000		$6,844,000		$6,441,000	
Total Construction Cost		$6,610,000		$24,870,000		$56,250,000		$17,373,000		$16,350,000	
Design & Administration		$1,322,000		$4,974,000		$11,250,000		$3,474,600		$3,270,000	
Total Project Cost		**$7,932,000**		**$29,844,000**		**$67,500,000**		**$20,847,600**		**$19,620,000**	
Annual Costs/Savings (in 2045)											
System Components	**System Size**	**Savings**	**System Size**	**Savings**	**System Size**	**Savings**	**System Size**	**Savings**	**System Size**	**Savings**	
Combined Heat and Power savings/ RNG & CNG sale	3 MW	$3,378,000	1.6 MW microturbines + 2.5 MW REEP, 500,000 Therm/year	$4,624,952	4.6 MW gas turbine + 2.5 MW REEP, 1,500,000 Therm/year	$7,925,000	RNG sale - 320 scfm + 2.5 MW REEP	$3,531,000	CNG sale - 320 scfm + 2.5 MW REEP	$4,781,000	$0.125/kWh, $0.50/Therm for heat savings and RNG sales, $1.50/GGE for CNG
RIN Incentives		-		-		-		$875,000		$1,800,000	$1.33 per GGE
LCFS Incentives		-		-		-		$660,000		$1,300,000	$8.83 per MMBTU
O&M	3 MW, 90% uptime	($970,000)	1.6 MW microturbines + 2.7 MW REEP, 90% uptime	($1,417,000)	4.6 MW gas turbine + 2.7 MW REEP, 90% uptime	($1,521,000)	320 scfm	($1,009,000)	320 scfm	($1,059,000)	Power & Labor
Repair/Replacement		($66,500)		($140,000)		($215,000)		($34,000)		($64,000)	2% of equipment cost
Net Annual Savings (2045)		**$2,341,500**		**$3,068,000**		**$6,189,000**		**$4,057,000**		**$6,822,000**	