Appendix C

Full-Scale Reservoir Augmentation Capacity Analysis Technical Memorandum

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Technical Memorandum

City of San Diego Water Purification Demonstration Project
Task 2 Conveyance Pipeline Concept Design Report

Subject:	**Full-scale Reservoir Augmentation Capacity Analysis**
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1 Purpose

The purpose of this Technical Memorandum (TM) is to determine an optimal capacity for a proposed full scale Advanced Water Purification project being served by excess recycled water from the North City Water Reclamation Plant (NCWRP). For the purpose of this analysis, optimum capacity is the capacity that adheres to the regulatory strategy developed as part of the Water Purification Demonstration Project (WPDP) while minimizing annual cost. This analysis does not consider the wastewater-related benefit of maximizing diversion from the Point Loma Wastewater Treatment Plant, which will also need to be considered when making a final decision on sizing the full-scale project. Based on the results of this TM, and the findings of the Recycled Water Study (to be completed in 2012), the City of San Diego (City) will choose a preliminary capacity for both the advanced water purification facility (AWPF) and the conveyance system, consisting of purified water pump station and conveyance pipeline to San Vicente Reservoir (SVR). This preliminary capacity will be the basis for facilities layout and cost estimation.

2 Findings

The following are findings for the AWPF and conveyance system facilities.

2.1 AWPF

This analysis was performed using two different wastewater plant flow concepts and an optimal AWPF capacity was determined for each concept. The first flow concept assumes available flow to the AWPF is comprised of tertiary effluent after subtracting utility water and recycled water demand and assuming tertiary filter and membrane filter (MF) backwash is wasted to Point Loma Wastewater Treatment Plant. The second flow concept assumes tertiary filter and MF backwash is recycled to the head of the NCWRP plant, thereby increasing available flow to the AWPF.

*Without returning Backwash Flows:*The results of this analysis determined an apparent optimal AWPF capacity when not recycling the backwash waters from tertiary or MF of 14 million gallons per day (mgd) for the full-scale project, yielding 14,270 AFY of purified water. The size of the AWPF is limited by the NCWRP capacity and the amount of water available after serving the recycled water demands. The AWPF plant capacity can be as high as 18 mgd with a product water yield of 15,730 AFY based on the projected recycled water demands and assumptions used in this analysis.

*With returning Backwash Flows:*An increase in AWPF production could be achieved if tertiary filter backwash and MF backwash is recycled to the front of the NCWRP rather than wasted to Point Loma Wastewater Treatment Plant. Under this operation, an optimal AWPF capacity of 18 mgd for a full-scale project would yield approximately 16,876 AFY of purified water. To maximize yield, the AWPF capacity could be up to 20 MGD. However the projected available flows to the AWPF after satisfying the recycled water demands would result in operation at 19 mgd for three months and operation at 20 mgd for one month out of the year.

Recycling of these flows is currently not part of the demonstration testing at NCWRP. The potential impacts to NCWRP and AWPF treatment processes are not anticipated to impact to the overall process but may have a slight increase in nitrogen as the return flows include chloraminated waters. The return flows could have an impact to the NCWRP operations however. Thus the point of re-entry and challenges to the operations as well as nitrogen limits should be evaluated further during the next phase of the project.

The cost analysis in Section 9 is presented for both flow scenarios: 1) assuming tertiary filter and MF backwash is not recycled to the head of the plant, and 2) assuming tertiary filter and MF backwash is recycled to the front of NCWRP.

2.2 Pump Station

Capacity will be sized to convey purified water from the AWPF to the SVR, and is directly dependent upon the AWPF capacity. To provide flexibility for future changes to planning decisions and flow projections; the footprint, power requirements, equipment space should be sized to house the number of pumps required to convey the maximum potential product water flow. This would allow the City to potentially increase the station capacity in stages without paying significant capital costs with each increase.

2.3 Pipeline

At the City's request, the pipeline diameter in this analysis was sized for the ultimate conveyance flow from the AWPF. The optimum product water that can be produced is projected to be approximately 18 mgd. Based on discussions with the City, the conveyance pipeline will be sized for the ultimate condition to avoid construction of a parallel pipeline to accommodate a phased capacity approach. Using City design guidelines and assumed flow projections, a 30-inch pipe was determined to be an appropriate diameter for ultimate condition in 2030. A 30-inch pipeline would have a velocity of approximately 5.7 ft/s, which is higher than the goal of 5 ft/s. Note that the energy analysis will confirm the pipeline diameter. The following economic analyses use a 30-inch conveyance pipeline size regardless of the AWPF capacity. This pipe size provides flexibility to address the range of flows under consideration while maintaining relatively low energy costs for pumping. Pipe diameter should be re-assessed as part of an energy/capital cost analysis under the conceptual design report when flow and pipeline alignment are more defined.

3 Sources of Information

In the City of San Diego Water Reuse Study (March 2006), approximately 10,500 acre-ft per year (AFY) was identified as being offset via a 16 mgd AWPF. The latest Recycled Water Study increased this recycled water use to 16,800 AFY. In addition to these studies, the WPDP team met with NCWRP staff to gain insight into current operations in order to verify the results of these previous studies.

The conveyance facilities used in this analysis are based on previous studies prepared for the City. The conveyance pipeline alignment is based on the South Corridor alignment that traverses along SR-52. This was originally identified in the *1996 Repurification Project Report, Volume 3 - Repurified Water Conveyance System* (1996 Project Report). The study recommended a 42-inch pipeline to carry up to 27 mgd of purified water to the SVR and suggested two potential alignments, Sycamore Canyon or Mast Boulevard Alignments. The Mast Boulevard alignment was selected and refined with the intent to progress to 30% design in the *1997 Repurified Water Conveyance System Technical Memorandum Final, Pipeline Alignment - Mast Boulevard* (30% Design Report). Additional studies including geotechnical investigation, corrosivity reports, transient analysis, environmental assessment, and preliminary construction cost estimates were prepared for the proposed alignment. The 27-mgd design flow and single pump station concept initially proposed in the 1996 Project Report were retained and included in the 30% Design Report.

For the purpose of this TM, the proposed Mast Boulevard South Corridor alignment that is approximately 28-miles in length (5 miles of which is already built) and the single pump station concept at the AWPF will be used in developing the life cycle costs for the conveyance facilities. An optimum AWPF flow rate will be determined in this evaluation, and associated conveyance facility sizes (pipeline diameter and pump station capacity) will be updated and used for capital and operations and maintenance costs.

The following is a list of previous studies referenced in this TM:

1. *Repurification Project Report, Volume 3 - Repurified Water Conveyance System, April 2006* (1996 Project Report) prepared by Montgomery Watson and Woodward-Clyde.

2. *Repurified Water Conveyance System (RWCS) Technical Memorandum (Final), Pipeline Alignment - Mast Boulevard, May 1997* (30% Design Report) prepared by Boyle Engineering Corporation.

3. *City of San Diego Water Reuse Study, Final Draft Report, March 2006* prepared by PBS&J.

4. *City of San Diego Water Reuse Study, Cost Analysis, Technical Memorandum 7 (September 2005)* prepared by PBS&J.

5. *City of San Diego* Recycled Water Study, prepared by Brown and Caldwell.

4 Project Components

The project components that will be analyzed in this TM include the AWPF, pump station facility at the AWPF to pump purified water to the San Vicente Reservoir, and the conveyance pipeline. Preliminary sizes and life cycle costs were determined for each of the components at varying capacities and flow rates. Costs developed for this analysis are intended for comparison purposes; not for the City's budgeting of capital improvement program for construction costs. The dechlorination facility (included in the 1990's evaluations), discharge structure, bike path improvements, and surge control facilities are not included in this analysis.

5 Methodology

The methodology employed for this analysis included the following activities:

- Preliminarily size pipeline and pump station for varying AWPF capacities
- Account for monthly irrigation demands in flows available for AWPF
- Determine life cycled costs for proposed facilities
- Conduct cost analysis to illustrate optimum capacity (yielding lowest unit cost per acre-ft)
- Use analysis to provide City with options and tradeoffs (cost implications of maximizing yield)

The optimal capacity analysis included an economic evaluation and a seasonal flow balance evaluation. The economic evaluation involved a comparison of the total project life cycle cost on an annual unit cost per acre-foot basis for AWPF capacities from 1 to 20 mgd and associated conveyance facilities. These project costs were further evaluated on an incremental basis to determine the increased cost of purified water produced by increasing the AWPF capacity by 1 mgd. This analysis was performed to identify when there is a diminishing return with increasing AWPF capacity. As the facility capacity increases it is oversized for a longer span of time throughout the year, particularly during the summer months when less flow is available to the plant due to irrigation demands. Therefore, there will be a breakpoint where the gain in product water yield starts to decrease with increasing incremental cost.

The seasonal flow balance evaluation involved balancing available flows to the AWPF capacity. This analysis was performed to strike a balance between having a plant sized for available flow once peak summer irrigation demands are met resulting in less product water to Point Loma Wastewater Treatment Plant during off peak demands and a facility that is oversized and unable to be fully utilized for many months. The ideal capacity is believed to be slightly larger or in excess of what is needed during peak demands but not too large such that a portion of the asset is rarely used. For this flow balance analysis, the

balanced AWPF capacity is assumed to be achieved when the excess recycled water to the facility is the same as the deficit in available recycled water for the year.

6 Projected Flows to the AWPF and Recommended Capacity

The amount of purified water that may be produced by the proposed AWPF is estimated by deducting the waste streams and recycled water demands from the projected wastewater inflow of 30 mgd for the year 2030. It is assumed that the NCWRP's design capacity would remain at 30 mgd during that time. At the outset of this TM, the planning year is 2030. The flow projections, plant capacity and recycled water demands are consistent with the Recycled Water Study. The flows that impact the product water volume are identified as follows:

- Sludge waste
- Filter Backwash
- Utility Water
- Recycled Water Demands from the Distribution System
- MF/ RO Waste

In addition, the ultimate yield of the project will be impacted by the AWPF on-line factor. The calculations for the Projected Flows based on Max Month Recycled Water Demands can be found in **Appendix A.**

6.1 Sludge

Sludge waste is comprised of primary sludge, secondary sludge and scum. Its concentration averages approximately 4,000 mg/L of total solids. Approximately 1.4 mgd of sludge is estimated to be removed from the NCWRP influent flow and pumped to the Metro Biosolids Center (MBC). This is based on actual plant data and recommended value provided by Lynn Chou (former Senior Civil Engineer who oversaw the daily plant operation at NCWRP).

6.2 Filter Backwash

Filter backwash at the NCWRP is estimated by assuming 0.2 mgd per backwash per day for 10 mgd of tertiary flow (or 2, according to Lynn Chou. To project for 28.6 mgd of tertiary flow, triple the backwash flow for an estimated 0.6 mgd of flow lost due to filter backwash.

Utility water for processing cooling, sealant, and wash down will flow to the plant drain and is approximately 0.8 mgd. An additional 0.5 mgd is used for on-site irrigation. The total utility water demand is approximate 1.3 mgd. However, this is already included in recycled water demand from the distribution system described below.

6.3 Recycled Water Demands

Recycled water demands from the distribution system that are primarily for irrigation purposes are seasonal. According to the latest Recycled Water Study, the average annual recycled demand projected between the years 2015 and 2030 is 9.1 mgd. Monthly factors that correlate the average annual demand to the average monthly demand are provided in **Table 1** and depicted in **Figure 1**.

As previously mentioned, the projected recycled water demand includes utility water at NCWRP. Since utility water flows to the plant drain are not seasonal, they are not subject to the monthly peaking factors and are subtracted before the monthly factors are applied.

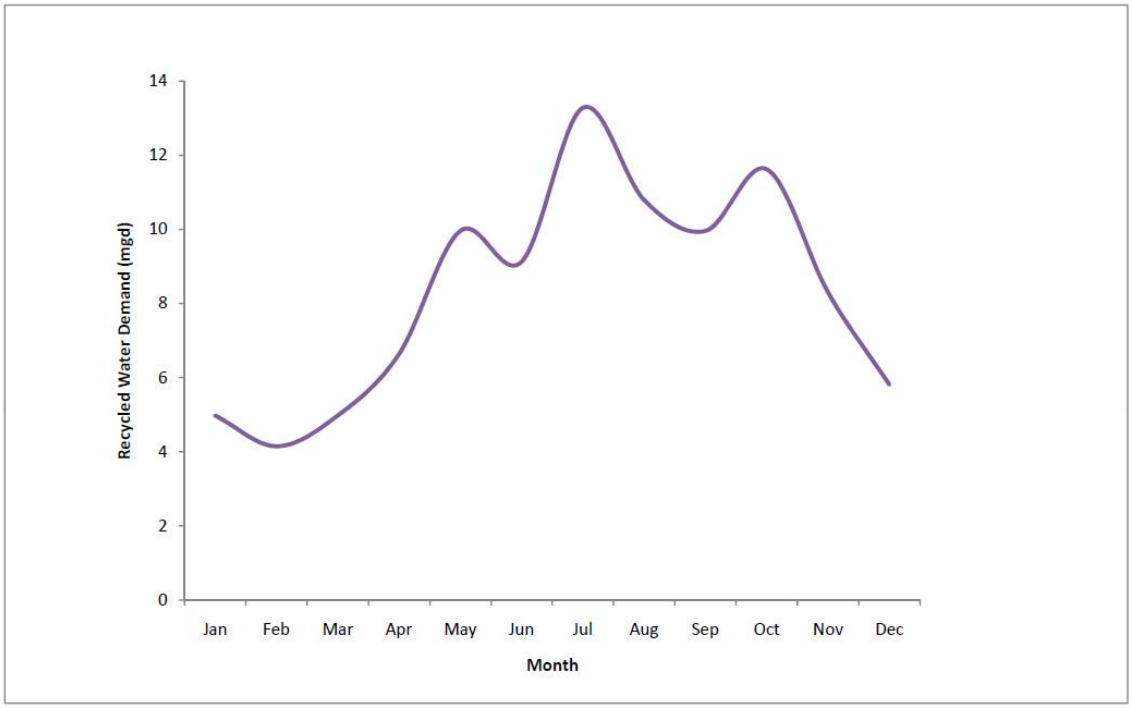
Table 1: Average Daily Recycled Water (RW) Demands by Month

Month	Avg Annual RW Demand (mgd)	Utility Water without Irrigation (mgd)	Irrigation RW Demands (mgd)	NCWRP RW Monthly Factor	Avg Daily Irrigation Demand by Month (mgd)
Jan	9.1	0.8	8.3	0.6	5.0
Feb	9.1	0.8	8.3	0.5	4.2
Mar	9.1	0.8	8.3	0.6	5.0
Apr	9.1	0.8	8.3	0.8	6.6
May	9.1	0.8	8.3	1.2	10.0
Jun	9.1	0.8	8.3	1.1	9.1
Jul	9.1	0.8	8.3	1.6	13.2
Aug	9.1	0.8	8.3	1.3	10.8
Sep	9.1	0.8	8.3	1.2	10.0
Oct	9.1	0.8	8.3	1.4	11.6
Nov	9.1	0.8	8.3	1.0	8.3
Dec	9.1	0.8	8.3	0.7	5.8

Note: NCWRP Recycled Water Monthly Factor obtained from Amy Dorman via email of Wed, June 8, 2011, 2:48:33PM. City referenced from latest Recycled Water Study.

After factoring in the above waste streams and recycled water demands, the remaining tertiary flow is available for the AWPF.

Figure 1: Average Daily Recycled Water Demands Curve



6.4 MF/ RO Waste

The available water will undergo membrane filtration (either micro- or ultra-filtration), and reverse osmosis (RO) at the AWPF. Each of these treatment processes will generate waste streams that would be

transported to the Point Loma Waste Water Treatment Plant. Recycling of backwash, also referred to as washwater, flows from MF is considered under this study as a potential scenario. The Independent Advisory Panel (IAP) discouraged recycling these flows, as expressed at the June 6, 2011 full IAP meeting.

Approximately 21.8% of the available flow supplying the AWPF is assumed to be wasted if MF backwash flows are not recycled. This waste percentage is consistent with the demonstration project currently underway at the NCWRP and represents 92% recovery for MF and 85% recovery for RO. Based on information collected from other AWPFs in southern California this is a reasonable assumption. The Los Angeles Water Replenishment District operates the Leo Van der Lans AWPF which has a biological treatment strategy that is closest to how the NCWRP operates utilizing nitrification and denitrification and operates with an overall 80% recovery.

6.5 On-line AWPF Operation

The AWPF is anticipated to operate continuously throughout the year. However, shutdown of the facility for maintenance and repairs for the AWPF throughout the year could occasionally interrupt or stop operation. An on-line percentage of 95% is assumed and factored into the amount of purified water produced annually when determining the unit cost per acre-foot of yield. In estimating the on-line percentage for the City, the operation of the Orange County Water District's (OCWD's) Ground Water Replenishment System in Fountain Valley, CA was investigated. The groundwater replenishment system treats secondary effluent and operates with 92% of the rated capacity on-line each year. Diurnal flow conditions limit the operation of the facility. OCWD anticipates increasing its on-line operation to 95% with the construction of equalization basins to attenuate the flow fluctuations. Since the NCWRP is equipped with flow equalization, an on-line percentage of 95% is assumed. This on-line operation is also used to estimate the pump station power usage for the year. The pump station is assumed to operate 24 hours per day, seven days a week with the exception of the annual shutdown resulting in an operation of approximately 347 days out of the year.

Figure 2 shows a schematic of the projected 2030 wastewater flow progression from the NCWRP through the AWPF to the final purified water product, and **Figure 3** shows a schematic of the flow progression with recycling of tertiary filter and MF backwash to the front of the plant. Example calculations of the estimated purified water product based on the apparent optimum AWPF capacity of 18 mgd with tertiary filter and MF backwash flows recycled to the front of the plant are provided as **Appendix A.**

Figure 2: Flow Progression from NCWRP to AWPF Purified Water Product (no recycle flows)

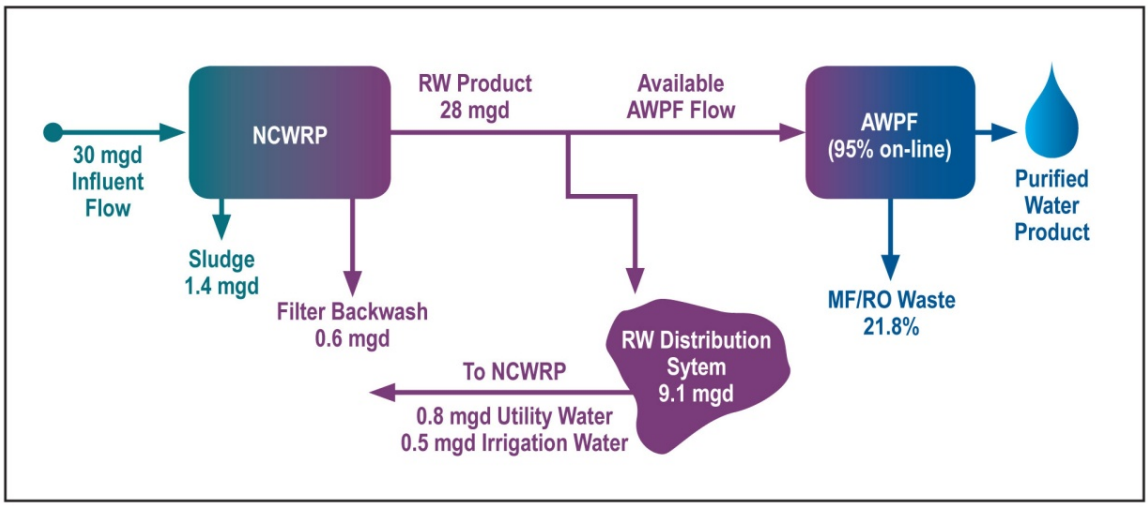
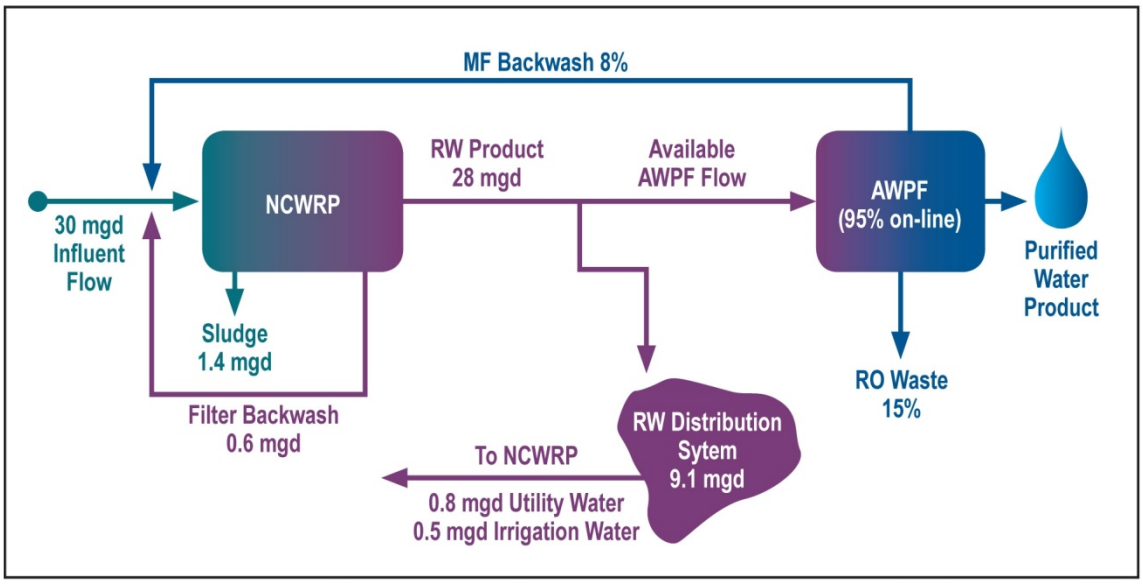


Figure 3: Flow Progression from NCWRP to AWPF Purified Water Product (with tertiary and MF backwash recycle)



7 Preliminary Design Criteria for Sizing Conveyance System

The design criteria and assumptions used in this analysis to preliminarily size the project components and determine the optimal AWPF capacity is provided in **Table 2**.

Table 2: Preliminary Facility Design Criteria

Facility	Criteria	Reference
Pipeline	Max Velocity = 5 ft/s Min Diameter = 8-inch Minor Losses = 10% of Friction Losses Hazen-Williams Coefficient = 135	*City of San Diego Water Department Capital Improvements Program Guidelines and Standards, Book 2*, November 2002 (City Guidelines and Standards).
Pump Station	Capacity = APWF Product Water Flow	Planned operation of AWPF at capacity
APWF	MF/ /RO Waste = 21.8% (8% MF Waste and 15% RO Waste) Online Factor = 95%	Based on Water Purification Demonstration Project performed by CDM Based on OCWD's Ground Water Replenishment System

For the purposes of this analysis, the 1996 Project Report recommendation of a single pump station at the AWPF to pump all of the purified water flows to the SVR will be used.

As previously mentioned, the selected pipeline alignment for this analysis is the South Corridor Mast Boulevard Alignment. The alignment is approximately 28-miles in length (5 miles of which is built) and extends from the AWPF to the SVR. The proposed alignment for this cost analysis assumes that the pipeline will connect to the existing recycled waterline that extends from the NCWRP to the MBC. The point of connection for the proposed conveyance pipeline would be to the existing 36-inch recycled water line at MBC. This would eliminate the construction of approximately 5 miles of pipeline.

8 Preliminary Project Life Cycle Costs

To help select the optimal capacity, preliminary costs in 2011 dollars have been developed. While these costs are not to be considered the programmatic costs, they are useful in comparing the relative and incremental costs or a given yield. The preliminary costs for the project components in this analysis were determined using the following cost assumptions summarized in **Table 3**. Sources for these assumptions include the 2005 Water Reuse Study, latest Recycled Water Study, data provided by the City, and assumed values based on typical industry standards.

Table 3: Facility Cost Assumptions

Facility	Cost Assumptions	Source
Capital Cost		
Pipeline	$20/in-dia/ft	Planning level unit cost includes some limited tunneling
Pump Station	PS Cost [1]= (440,000*(Q_{cfs})^0.75 * (H_{ft}/300)^0.66)	*Water Reuse Study, Cost Analysis, Technical Memorandum 7 (September 2005)*
AWPF	MF: $1,410,000/mgd RO: $1,750,000/mgd AOP: $310,000/mgd	Provided by City and rounded to nearest $10,000
O&M Cost		
Pipeline	1% of Construction Cost[2]	*Water Reuse Study, Cost Analysis, Technical Memorandum 7 (September 2005)*
Pump Station	2.5% of Construction Cost[2]	*Water Reuse Study, Cost Analysis, Technical Memorandum 7 (September 2005)*
	Pump Hrs per Day = 24 hrs	Assumed
	Days per Year = 95% of 365 days = 347 days	Based on AWPF on-line factor
	Wire to Water Pumping Efficiency = 75%	Assumed
	Energy Cost = $0.15/kWh	Assumed
AWPF	MF/RO/AOP: $600,000/mgd	Latest Recycled Water Study and rounded to nearest $10,000
Soft Costs		
Life Cycle	50 years	Apply to all facilities. Provided by City
Interest Rate	6%	*Water Reuse Study, Cost Analysis, Technical Memorandum 7 (September 2005)*
Contingency	40%	Provided by City
Engineering/Admin	20%	Provided by City
Environmental Doc	20%	Provided by City
Land Acquisition	4%	Provided by City
Construction Mgmt	10%	Provided by City

Notes:
1. The original pump station capital cost equation from *Water Reuse Study, Cost Analysis, Technical Memorandum 7 (September 2005)* included 30% administrative & engineering fees and 20% construction management fees. These were removed as soft costs provided by the City would be factored in later.
2. Pump station and pipeline O&M Costs is percentage of construction cost with 40% soft cost contingency factored into construction cost.

3. AWPF O&M costs for microfiltration, reverse osmosis, and advanced oxidation process provided by City was compared to OCSD's AWPF that produces 49 mgd of product water. OCWD in November 2008 had operating costs of $573k/mgd which includes $10k/mgd of OCSD credits. The difference of $17k/mgd can be attributed to data being 3 years ago and economies of scale.

9 Cost Analysis

As part of the cost analysis, the total project cost was estimated for varying AWPF capacities to determine an optimal unit cost per acre-foot of purified water produced annually. This analysis was done first assuming tertiary filter and MF backwash flows are wasted to Point Loma Wastewater Treatment Plant (Section 9.1), and next assuming tertiary filter and MF backwash flows are recycled to the head of the NCWRP (Section 9.2).

9.1 Cost Analysis Assuming No Recycle Flows

Table 4 summarizes the unit costs for the preliminarily sized pump station, ultimate conveyance pipeline diameter of 30-inch, and purified product water yield for AWPF capacities varying from 0 to 20 mgd. A complete detailed cost breakdown showing costs for each project component is provided as **Appendix B**.

Table 4: Purified Water Yields and Project Unit Costs by AWPF Capacity (no recycle flows)

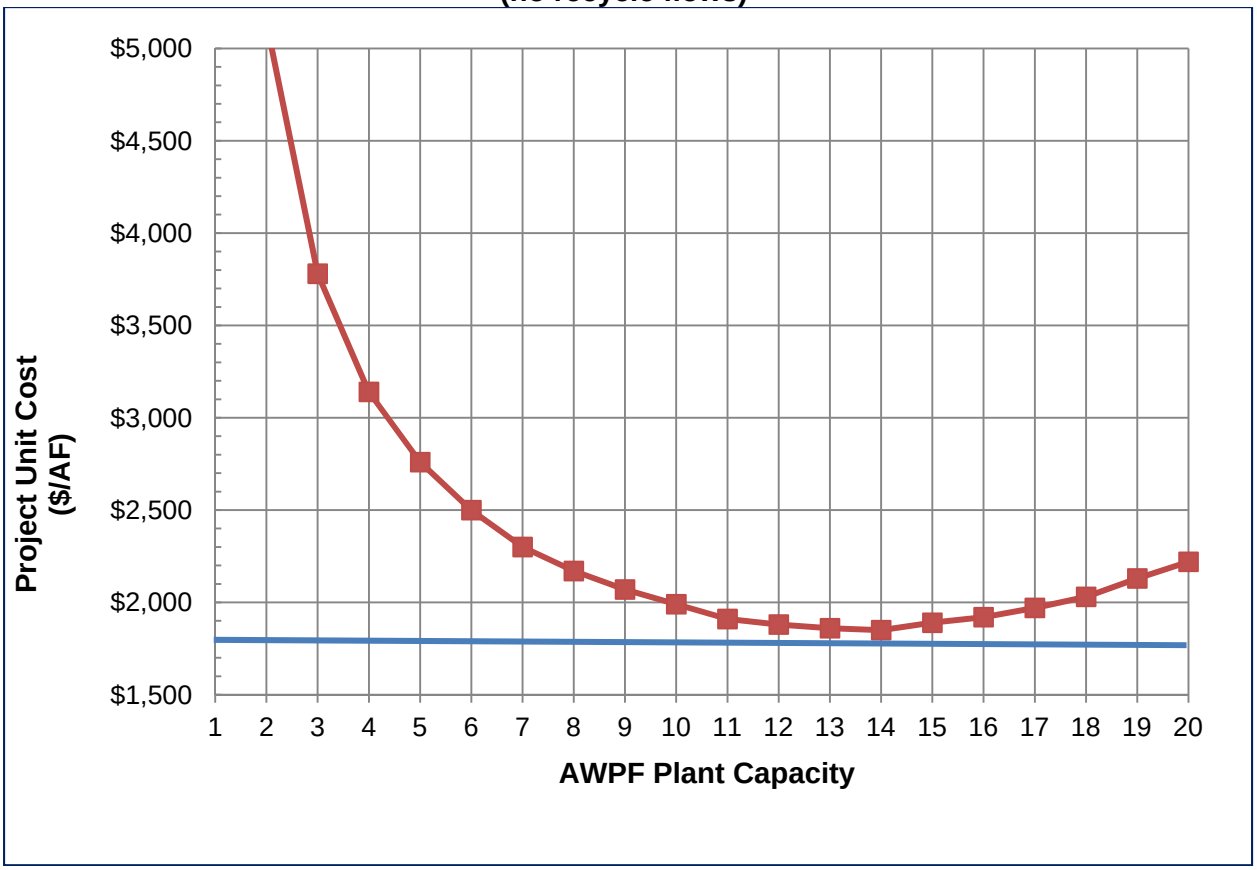
AWPF Plant Capacity (mgd)	Projected AWPF Product Water Yield (95% on-line) (AFY)	Conveyance Pipe Diameter (in)	Pump Flow (gpm)	TDH (ft)	Pump Power (Hp)	Unit Cost ($/AFY)
1	1,070	30	700	450	110	$8,970
2	2,130	30	1,400	450	220	$5,140
3	3,210	30	2,100	460	330	$3,780
4	4,270	30	2,800	460	440	$3,140
5	5,330	30	3,500	470	560	$2,760
6	6,400	30	4,200	480	680	$2,500
7	7,460	30	4,900	500	830	$2,300
8	8,530	30	5,600	510	970	$2,170
9	9,590	30	6,300	530	1130	$2,070
10	10,650	30	7,000	550	1300	$1,990
11	11,710	30	7,700	560	1460	$1,910
12	12,680	30	8,400	590	1670	$1,880
13	13,570	30	9,100	610	1870	$1,860
14	**14,270**	**30**	**9,800**	**630**	**2080**	**$1,850**
15	14,800	30	10,500	660	2340	$1,890
16	15,240	30	11,200	680	2570	$1,920
17	15,580	30	11,900	710	2850	$1,970
18	15,740	30	12,500	740	3120	$2,030
19	15,740	30	13,200	770	3430	$2,130
20	15,740	30	13,900	810	3800	$2,220

Notes:
1. Pipeline diameter sizes are based on a maximum velocity of 5 feet per second per *City of San Diego CIP Guidelines and Standards* for transmission mains less than 60-inch in diameter.
2. Estimated Projected AWPF Water Yield includes the 5% off-line factor.

Based on the unit cost per acre-foot cost analysis, Table 4 and **Figure 4** illustrate the apparent optimal price point is at an AWPF capacity of 14 mgd with an estimated unit cost of $1,850 per acre-feet of purified water produced annually. However, this analysis is based on the projected recycled water demands for 2030 (which may vary over the next 19 years) and concept level costs. Because of the potential variations in the assumptions, an optimum range would be reasonable as the differences in unit costs are within a narrow margin. Therefore, AWPF feed rates within the lower and flatter segment of the curve (from 11 to 16 mgd) are within an optimal range with 14 mgd estimated as having the lowest unit cost per acre-foot of product water yield. This range provides the City some flexibility in capturing the flows when the irrigation demands are less, thus avoiding lost product water to Point Loma Wastewater Treatment Plant.

Per the City's request, a separate analysis was performed assuming an ultimate 36-inch pipe diameter would be constructed. Similar to evaluating the economic analysis with a constant 30-inch pipe, this was performed to determine the cost implications the pipe capital cost would have on the project unit cost, as well as the overall project costs. The results of this analysis are included in **Appendix C**.

Figure 4: Project Unit Cost by AWPF Plant Capacity for 30-inch Pipe (no recycle flows)

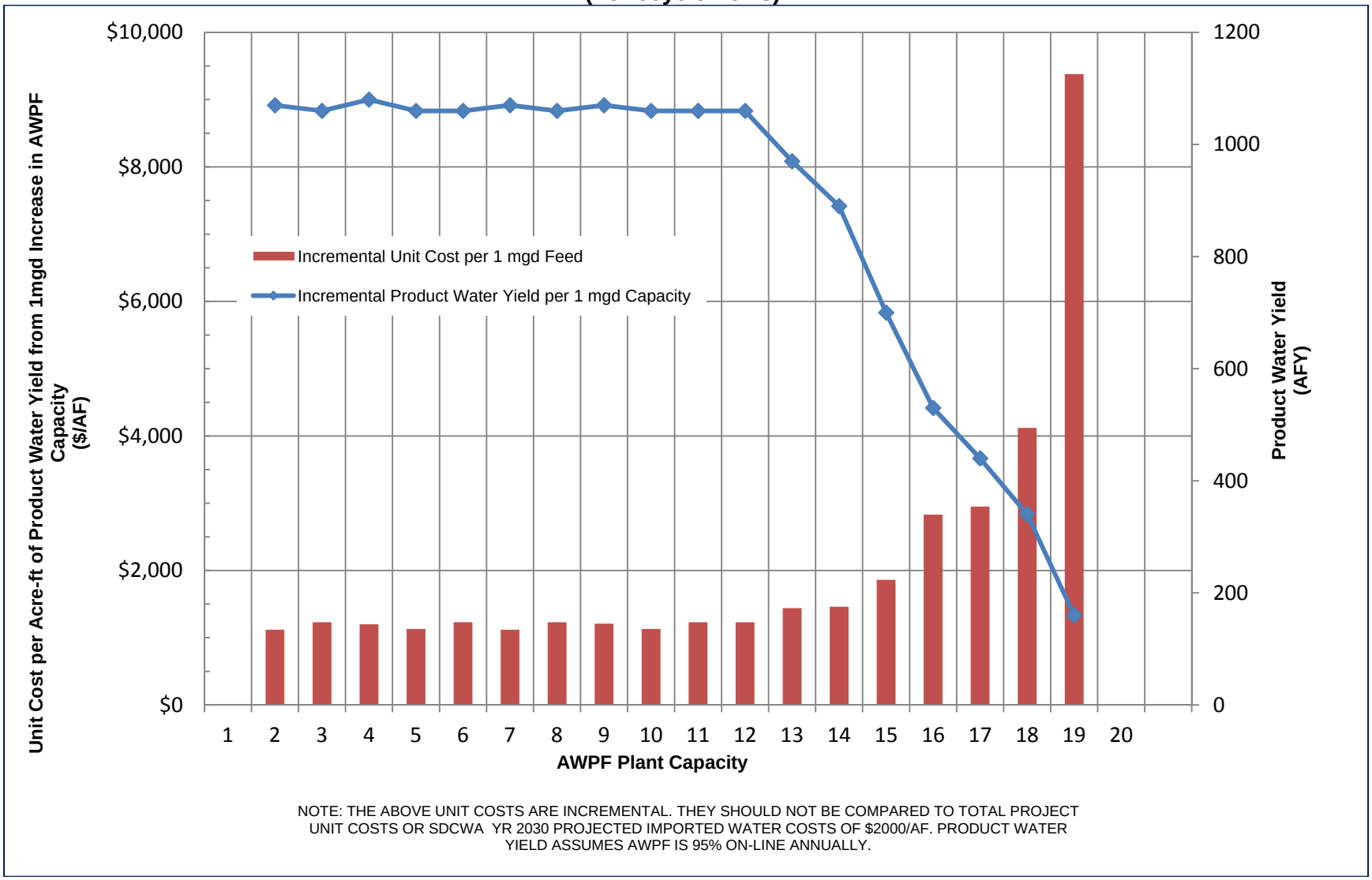


Another way to analyze the capacity is to look at the incremental costs for each additional 1 mgd of flow. **Table 5** below shows the incremental product water yield and total project costs for each additional increase in 1-mgd of AWPF feed rate. The incremental cost per 1mgd of capacity starts to increase at an increasing rate at 14 mgd and above.

Figure 5 shows the purified water yield for each additional 1 mgd of AWPF feed along with the "incremental" unit cost per acre-foot. The amount of product water yield from the AWPF begins to decrease for feed rates greater than 14 mgd because seasonal recycled water demands impact the amount of tertiary water available for advanced treatment. As the AWPF capacity increases, the product water yield diminishes because the facility is oversized for longer periods of time during the summer months when available tertiary flows to the purification facility are lowest. This incremental unit cost should not be confused with the overall project unit cost where annualized project costs are divided by the average annual purified water yield.

Based on the incremental unit cost analysis, the product water yield starts to decline for AWPF capacities that are greater than 11 mgd. Even for capacities from 12 to 14 mgd, it appears that the incremental costs are relatively comparable in cost despite the decline in product water yield. An AWPF capacity of 14 mgd is the breakpoint where the benefit to cost ratio starts to decline more dramatically.

Figure 5: Incremental Unit Cost of Purified Water Yield Per 1 MGD Increase of AWPF Capacity (no recycle flows)



NOTE: THE ABOVE UNIT COSTS ARE INCREMENTAL. THEY SHOULD NOT BE COMPARED TO TOTAL PROJECT UNIT COSTS OR SDCWA YR 2030 PROJECTED IMPORTED WATER COSTS OF $2000/AF. PRODUCT WATER YIELD ASSUMES AWPF IS 95% ON-LINE ANNUALLY.

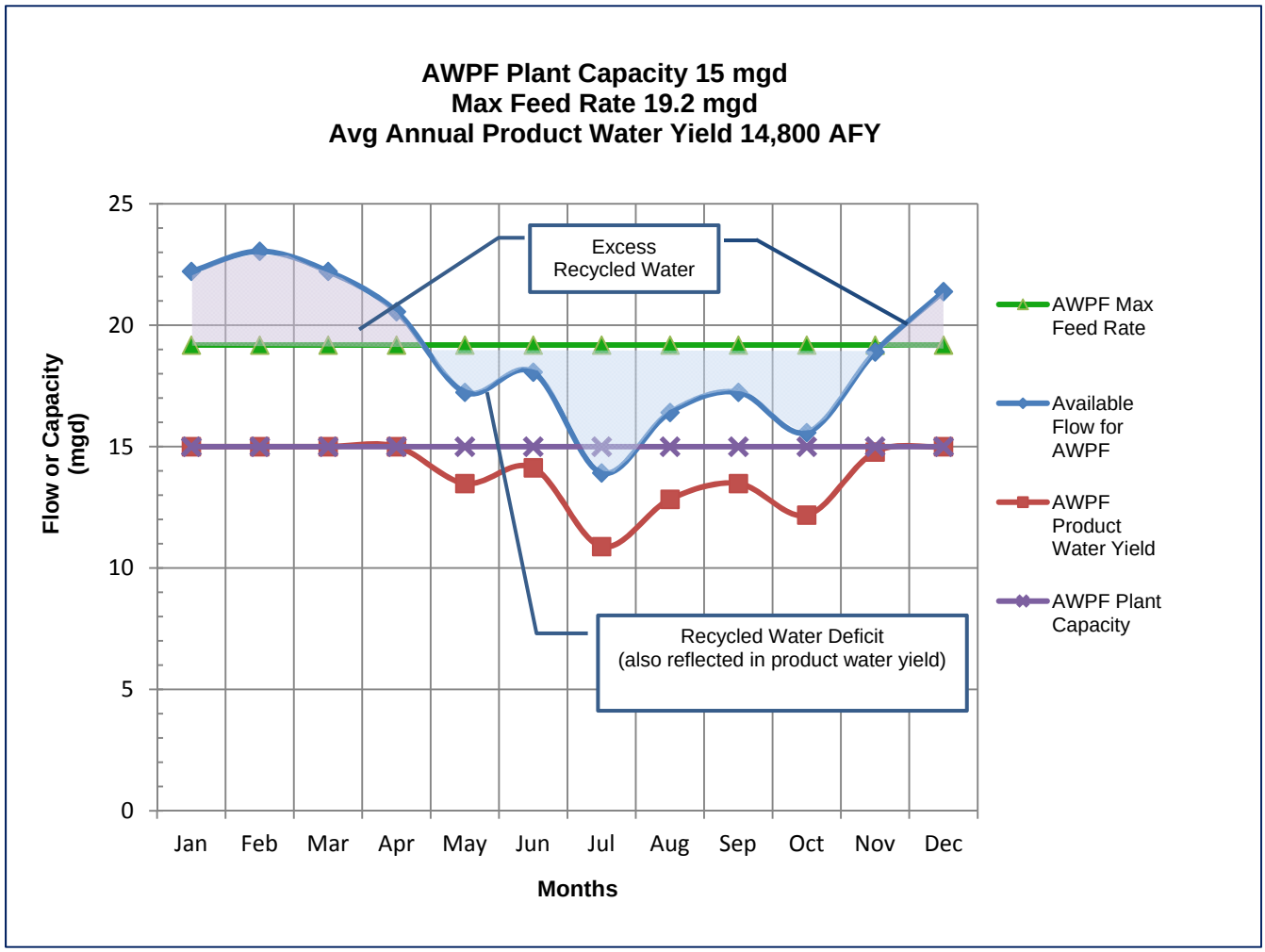
Table 5: Incremental Unit Cost by AWPF Capacity (no recycle flows)

AWPF Capacity (mgd)	Conveyance Pipe Diameter (in)	AWPF Product Water Yield (95% on-line) (AFY)	Incremental AWPF Capacity (AFY)	Incremental Capital Cost ($)	Incremental Annual O&M Cost ($)	Incremental Total Annual Cost ($)	Incremental Unit Cost ($/AF)
1	30	1,070	1,070	$8,300,000	$600,000	$1,200,000	$1,120
2	30	2,130	1,060	$7,900,000	$700,000	$1,300,000	$1,230
3	30	3,210	1,080	$7,900,000	$600,000	$1,300,000	$1,200
4	30	4,270	1,060	$7,800,000	$700,000	$1,200,000	$1,130
5	30	5,330	1,060	$7,800,000	$700,000	$1,300,000	$1,230
6	30	6,400	1,070	$7,800,000	$600,000	$1,200,000	$1,120
7	30	7,460	1,060	$7,800,000	$600,000	$1,300,000	$1,230
8	30	8,530	1,070	$7,800,000	$700,000	$1,300,000	$1,210
9	30	9,590	1,060	$7,900,000	$600,000	$1,200,000	$1,130
10	30	10,650	1,060	$7,800,000	$600,000	$1,300,000	$1,230
11	30	11,710	1,060	$7,800,000	$600,000	$1,300,000	$1,230
12	30	12,680	970	$8,000,000	$700,000	$1,400,000	$1,440
13	30	13,570	890	$7,900,000	$700,000	$1,300,000	$1,460
14	**30**	**14,270**	**700**	**$7,900,000**	**$600,000**	**$1,300,000**	**$1,860**
15	30	14,800	530	$8,000,000	$700,000	$1,500,000	$2,830
16	30	15,240	440	$7,900,000	$600,000	$1,300,000	$2,950
17	30	15,580	340	$8,100,000	$600,000	$1,400,000	$4,120
18	30	15,740	160	$8,000,000	$700,000	$1,500,000	$9,380
19	30	15,740	0	$8,100,000	$600,000	$1,400,000	---
20	30	15,740	0	$8,200,000	$700,000	$1,500,000	---

Note: The above flow data and costs are based on 30-inch pipe.

From an economic analysis, the optimum value appears to occur from an AWPF capacity of 14 mgd which produces a projected product yield of 14,270 AFY at a required feed flow of 17.9 mgd. Although it would treat less recycled water during the winter months than the balanced scenario, it would potentially operate at its design capacity for 9 months out of a given year depending upon recycled water demands.

Figure 6: Flow Balance Analysis
(no recycle flows)



9.2 Cost Analysis with Tertiary/MF Recycle Flows

Table 6 summarizes the unit costs for the preliminarily sized pump station, ultimate conveyance pipeline diameter of 30-inch, and purified product water yield for AWPF capacities varying from 0 to 20 mgd assuming tertiary filter and MF backwash flows are recycled to the front of the NCWRP. Recycling flows to the front of the plant will increase flow to the AWPF, increasing monthly yield when plant capacity exceeds the flow available. A complete detailed cost breakdown showing costs for each project component is provided as **Appendix B**.

Table 6: Purified Water Yields and Project Unit Costs by AWPF Capacity (with tertiary and MF backwash recycle)

AWPF Plant Capacity (mgd)	Projected AWPF Product Water Yield (95% on-line) (AFY)	Conveyance Pipe Diameter (in)	Pump Flow (gpm)	TDH (ft)	Pump Power (Hp)	Unit Cost ($/AFY)
1	1,070	30	700	450	110	$8,970
2	2,130	30	1,400	450	220	$5,140
3	3,210	30	2,100	460	330	$3,780
4	4,270	30	2,800	460	440	$3,140
5	5,330	30	3,500	470	560	$2,760
6	6,400	30	4,200	480	680	$2,500
7	7,460	30	4,900	500	830	$2,300
8	8,530	30	5,600	510	970	$2,170
9	9,590	30	6,300	530	1130	$2,070
10	10,650	30	7,000	550	1300	$1,990
11	11,720	30	7,700	560	1460	$1,910
12	12,780	30	8,400	590	1670	$1,870
13	13,770	30	9,100	610	1870	$1,820
14	14,700	30	9,800	630	2080	$1,800
15	15,510	30	10,500	660	2340	$1,800
16	16,100	30	11,200	680	2570	$1,820
17	16,570	30	11,900	710	2850	$1,850
18	**16,990**	**30**	**12,500**	**740**	**3120**	**$1,900**
19	17,290	30	13,200	770	3430	$1,940
20	17,370	30	13,900	810	3800	$2,030

Notes:

3. Pipeline diameter sizes are based on a maximum velocity of 5 feet per second per *City of San Diego CIP Guidelines and Standards* for transmission mains less than 60-inch in diameter.
4. Estimated Projected AWPF Water Yield includes the 5% off-line factor.

Based on the unit cost per acre-foot cost analysis, **Table 6** and **Figure 7,** AWPF feed rates within the lower and flatter segment of the curve (from 11 to 18 mgd) are within an optimal range with 14 to 15 mgd estimated as having the lowest unit cost per acre-foot of product water yield. This is because at 14 to 15 MGD the plant would operate at full capacity nearly year round. However, at a capacity of approximately 18 MGD, the City would be able to meet the stated IPR goals.

Figure 7: Project Unit Cost by AWPF Plant Capacity for 30-inch Pipeline (with tertiary and MF backwash recycle)

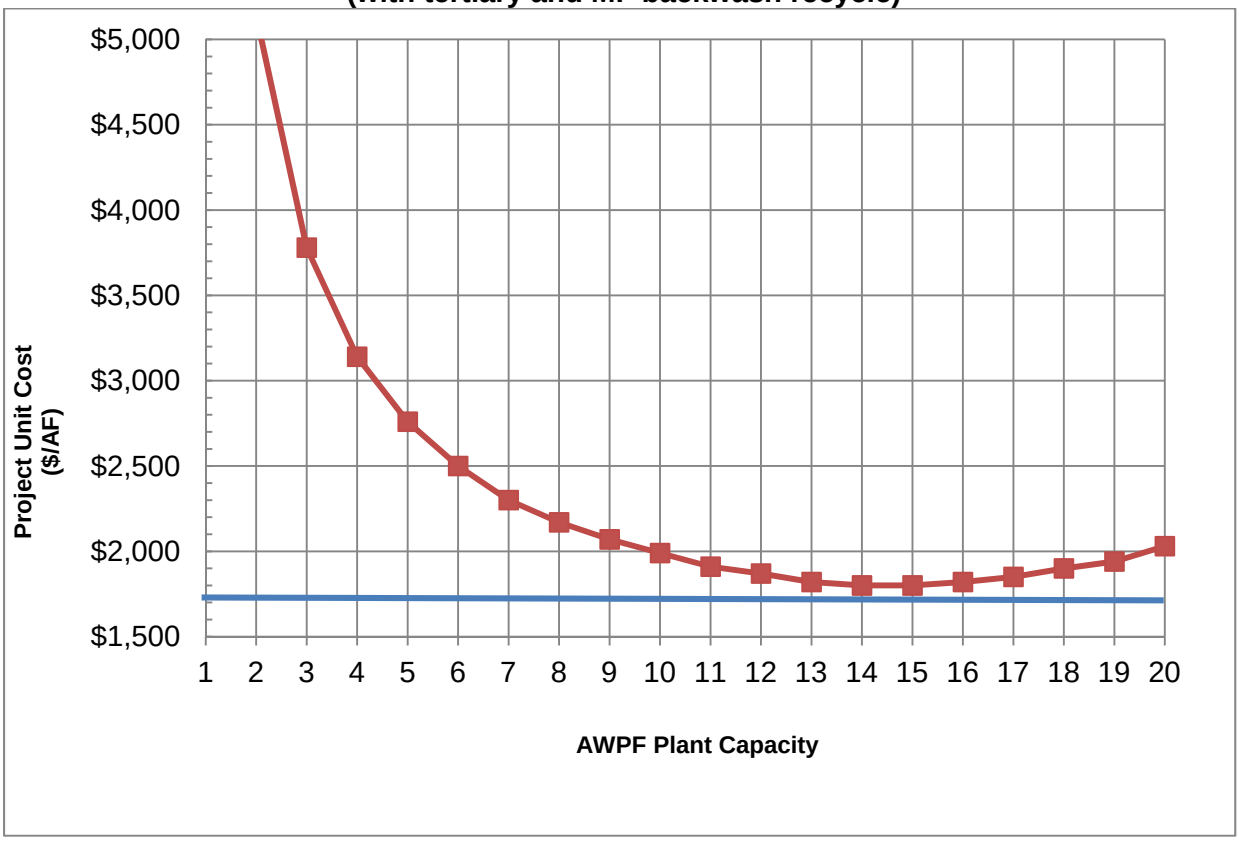
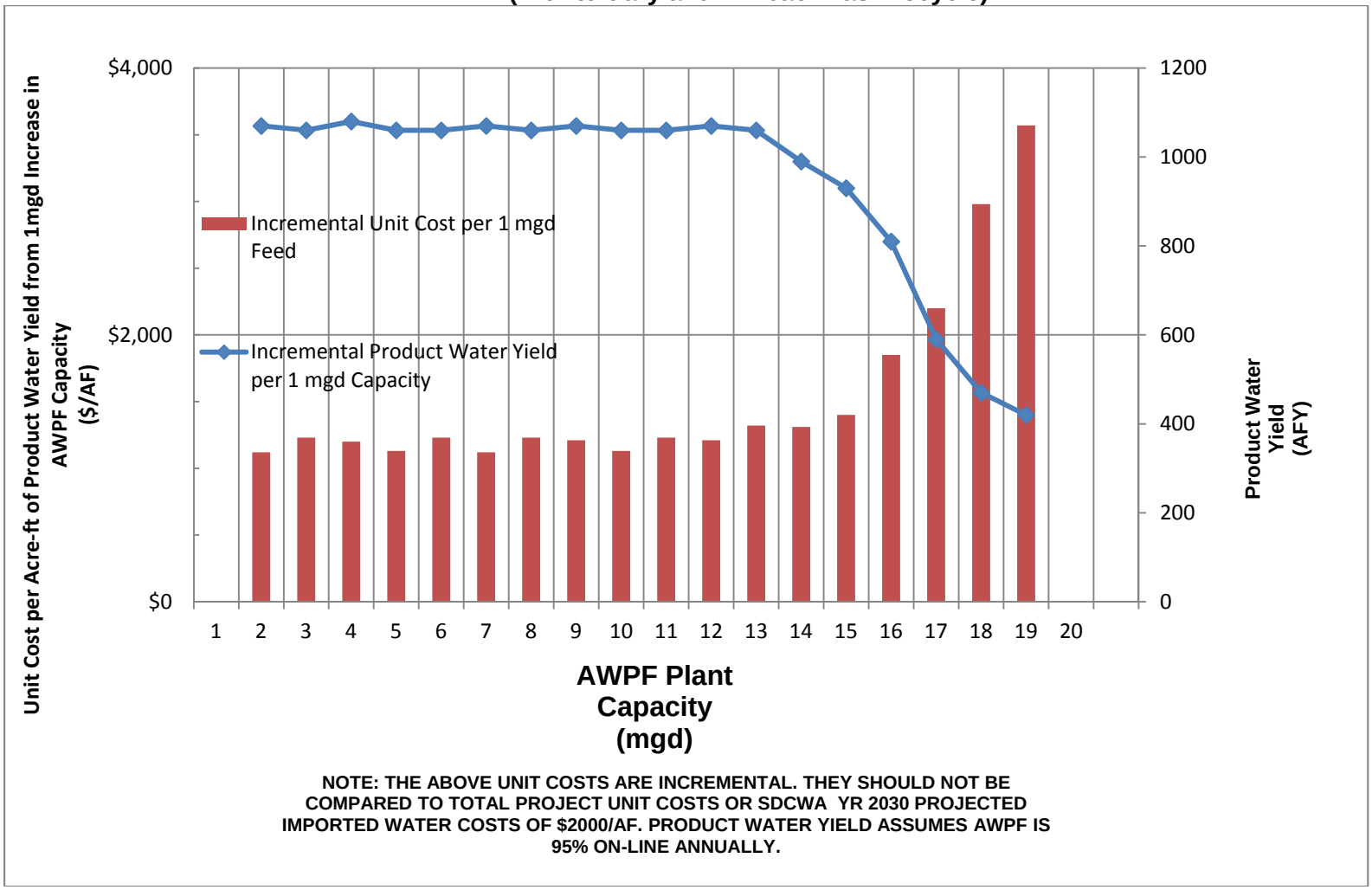


Table 7 shows the incremental product water yield and total project costs for each additional increase in 1-mgd of AWPF feed rate with recycle flows. The incremental cost per 1 mgd of capacity starts to increase at an increasing rate at 16 mgd and above.

Figure 8 shows the purified water yield for each additional 1 mgd of AWPF feed along with the "incremental" unit cost per acre-foot. The amount of product water yield from the AWPF begins to decrease for feed rates greater than 14 mgd because seasonal recycled water demands impact the amount of tertiary water available for advanced treatment. As the AWPF capacity increases, the product water yield diminishes because the facility is oversized for longer periods of time during the summer months when available tertiary flows to the purification facility are lowest.

Figure 8: Incremental Unit Cost and Purified Water Yield per 1 MGD Increase of AWPF Capacity (with tertiary and MF backwash recycle)



NOTE: THE ABOVE UNIT COSTS ARE INCREMENTAL. THEY SHOULD NOT BE COMPARED TO TOTAL PROJECT UNIT COSTS OR SDCWA YR 2030 PROJECTED IMPORTED WATER COSTS OF $2000/AF. PRODUCT WATER YIELD ASSUMES AWPF IS 95% ON-LINE ANNUALLY.

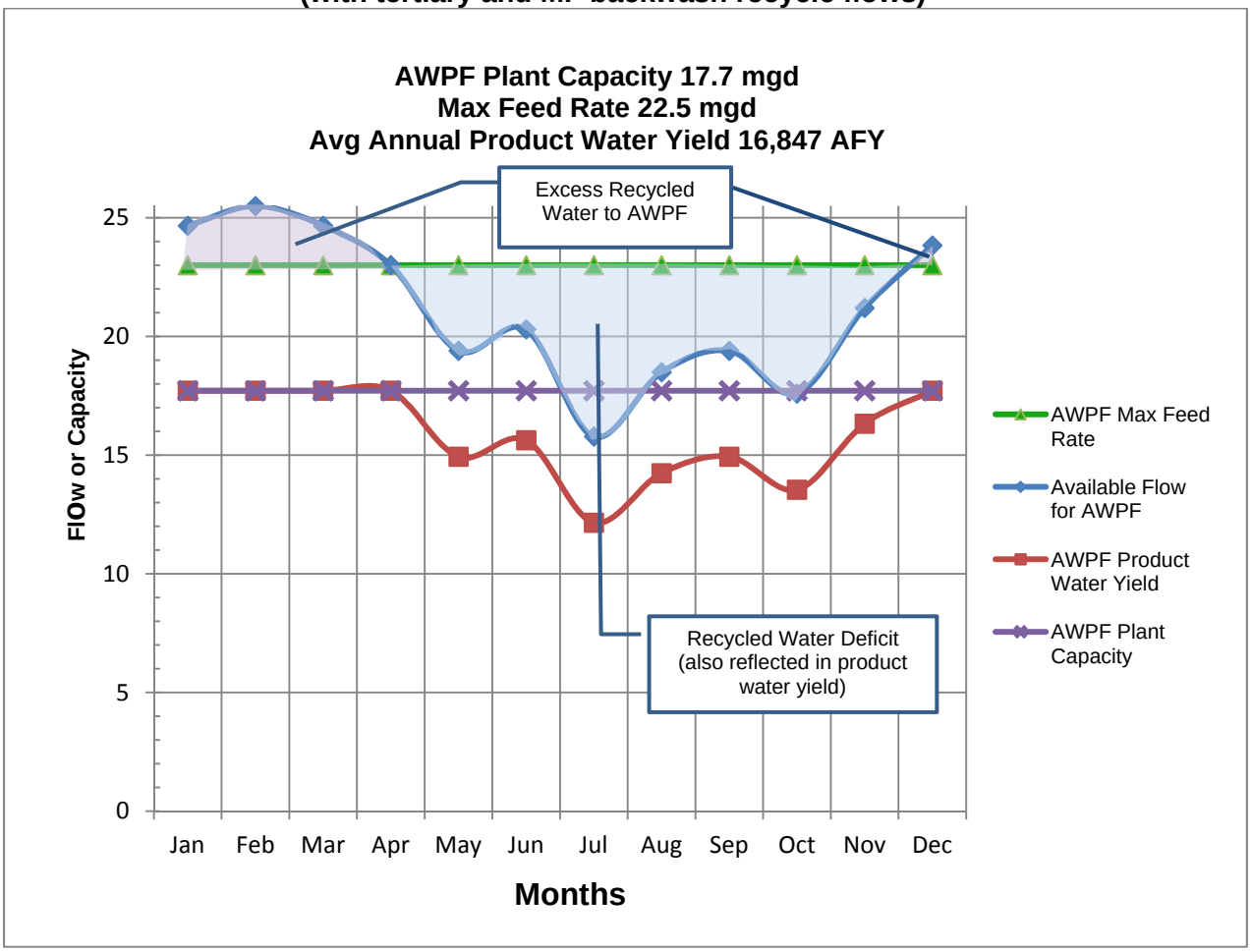
Table 7: Incremental Unit Cost by AWPF Capacity (with tertiary and MF backwash recycle)

AWPF Capacity (mgd)	Conveyance Pipe Diameter (in)	AWPF Product Water Yield (95% on-line) (AFY)	Incremental AWPF Capacity (AFY)	Incremental Capital Cost ($)	Incremental Annual O&M Cost ($)	Incremental Total Annual Cost ($)	Incremental Unit Cost ($/AF)
1	30	1,070	1,070	$8,300,000	$600,000	$1,200,000	$1,120
2	30	2,130	1,060	$7,900,000	$700,000	$1,300,000	$1,230
3	30	3,210	1,080	$7,900,000	$600,000	$1,300,000	$1,200
4	30	4,270	1,060	$7,800,000	$700,000	$1,200,000	$1,130
5	30	5,330	1,060	$7,800,000	$700,000	$1,300,000	$1,230
6	30	6,400	1,070	$7,800,000	$600,000	$1,200,000	$1,120
7	30	7,460	1,060	$7,800,000	$600,000	$1,300,000	$1,230
8	30	8,530	1,070	$7,800,000	$700,000	$1,300,000	$1,210
9	30	9,590	1,060	$7,900,000	$600,000	$1,200,000	$1,130
10	30	10,650	1,060	$7,800,000	$600,000	$1,300,000	$1,230
11	30	11,720	1,070	$7,800,000	$600,000	$1,300,000	$1,210
12	30	12,780	1,060	$8,000,000	$700,000	$1,400,000	$1,320
13	30	13,770	990	$7,900,000	$700,000	$1,300,000	$1,310
14	30	14,700	930	$7,900,000	$600,000	$1,300,000	$1,400
15	30	15,510	810	$8,000,000	$700,000	$1,500,000	$1,850
16	30	16,100	590	$7,900,000	$600,000	$1,300,000	$2,200
17	30	16,570	470	$8,100,000	$600,000	$1,400,000	$2,980
18	**30**	**16,990**	**420**	**$8,000,000**	**$700,000**	**$1,500,000**	**$3,570**
19	30	17,290		$8,100,000	$600,000	$1,400,000	
20	30	17,370		$8,200,000	$700,000	$1,500,000	

Note: The above flow data and costs are based on 30-inch pipe.

Calculations of treatment capacity and AWPF yield show that a 17.7 MGD plant can meet the City's goal of 16,800 AFY IPR reuse. **Figure 9** shows the amount of recycled water above and below the AWPF capacity by month for a 17.7 MGD AWPF, including excess recycled water available to the AWPF and deficit recycled water (excess AWPF capacity). For approximately 7 months out of the year, the flow available is less than required for the plant to run at full capacity. However, this is the minimum size plant that would meet the City's IPR goals.

Figure 9: Flow Balance Analysis
(with tertiary and MF backwash recycle flows)



10 Conclusion

As discussed earlier, flows available to the AWPF vary by season throughout the year. After on-site and irrigation demands are met, the maximum month available flow would be 25 mgd with recycling tertiary filter and MF backwash flows. Without recycling the tertiary filter and MF backwash flows the AWPF and pumping facilities should be sized for 14 mgd of capacity initially and 18 mgd for ultimate. **Table 8** summarizes the project costs by component and highlights the two recommended AWPF capacities. However, an increase in AWPF production could be achieved if tertiary filter backwash and membrane filtration (MF) backwash is recycled back to the front of the plant rather than wasted to Point Loma Wastewater Treatment Plant. If this scenario is implemented, an optimal AWPF capacity of 18 mgd for a full-scale project would yield approximately 16,876 AFY of purified water, which meets the City's goal of maximizing reuse. **Table 9** summarizes the project costs by component and highlights the recommended AWPF capacity.

Recycling of these flows is not part of the current operations at the NCWRP or at the pilot demonstration tests facility. The NCWRP plant staff believes that they can process more flow than the rated capacity but is actually operating well below the rated capacity and does not have a track record of performance above 30 mgd. In the future and with recycling the tertiary and MF backwash flows, the NCWRP could see flows greater than 10% above the rated capacity on a continuous basis. Note that this analysis did not evaluate the hydraulics or process design capabilities and limitations. The MF backwash water contains chloramines and thus would add more nitrogen back into the NCWRP from recycling this water. While the load may be relatively small, total nitrogen is a key regulatory parameter for reservoir augmentation. Therefore, potential water quality impacts and mitigation measures should be evaluated in the next phase of the design. In addition, recycling of these flows would deliver more flow to the front of the NCWRP, and potential impacts to NCWRP operations, including available process capacity must be evaluated.

Table 8: Project Cost Summary by AWPF Capacity (no recycle flows)

AWPF Capacity (mgd)	AWPF Product Water Yield (95% online) (AFY)	Construction Costs Total ($)	Soft Costs Total ($)	Capital Costs				Annualized Capital Costs Total ($)	Annualized O&M Costs Total ($)	Total Annualized Cost Total ($)	Annual Unit Cost Total ($/AF)
				AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)				
1	1,070	$65,100,000	$61,200,000	$7,220,000	$118,000,000	$1,032,000	$126,300,000	$8,100,000	$1,500,000	$9,600,000	$8,970
2	2,130	$69,200,000	$65,100,000	$14,430,000	$118,000,000	$1,734,000	$134,200,000	$8,600,000	$2,200,000	$10,900,000	$5,140
3	3,210	$73,300,000	$68,900,000	$21,650,000	$118,000,000	$2,386,000	$142,100,000	$9,100,000	$2,800,000	$12,200,000	$3,780
4	4,270	$77,300,000	$72,700,000	$28,860,000	$118,000,000	$2,960,000	$149,900,000	$9,600,000	$3,500,000	$13,400,000	$3,140
5	5,330	$81,300,000	$76,400,000	$36,080,000	$118,000,000	$3,550,000	$157,700,000	$10,000,000	$4,200,000	$14,700,000	$2,760
6	6,400	$85,300,000	$80,200,000	$43,290,000	$118,000,000	$4,128,000	$165,500,000	$10,500,000	$4,800,000	$15,900,000	$2,500
7	7,460	$89,400,000	$84,000,000	$50,510,000	$118,000,000	$4,761,000	$173,300,000	$11,000,000	$5,400,000	$17,200,000	$2,300
8	8,530	$93,400,000	$87,800,000	$57,720,000	$118,000,000	$5,331,000	$181,100,000	$11,500,000	$6,100,000	$18,500,000	$2,170
9	9,590	$97,400,000	$91,600,000	$64,930,000	$118,000,000	$5,973,000	$189,000,000	$12,000,000	$6,700,000	$19,700,000	$2,070
10	10,650	$101,500,000	$95,400,000	$72,150,000	$118,000,000	$6,623,000	$196,800,000	$12,500,000	$7,300,000	$21,000,000	$1,990
11	11,710	$105,500,000	$99,200,000	$79,360,000	$118,000,000	$7,199,000	$204,600,000	$13,000,000	$7,900,000	$22,300,000	$1,910
12	12,680	$109,600,000	$103,000,000	$86,580,000	$118,000,000	$7,954,000	$212,600,000	$13,500,000	$8,600,000	$23,700,000	$1,880
13	13,570	$113,700,000	$106,900,000	$93,790,000	$118,000,000	$8,635,000	$220,500,000	$14,000,000	$9,300,000	$25,000,000	$1,860
14	**14,270**	**$117,800,000**	**$110,700,000**	**$101,010,000**	**$118,000,000**	**$9,324,000**	**$228,400,000**	**$14,500,000**	**$9,900,000**	**$26,300,000**	**$1,850**
15	14,800	$121,900,000	$114,600,000	$108,220,000	$118,000,000	$10,125,000	$236,400,000	$15,000,000	$10,600,000	$27,800,000	$1,890
16	15,240	$126,000,000	$118,400,000	$115,440,000	$118,000,000	$10,839,000	$244,300,000	$15,500,000	$11,200,000	$29,100,000	$1,920
17	15,580	$130,100,000	$122,300,000	$122,650,000	$118,000,000	$11,671,000	$252,400,000	$16,100,000	$11,800,000	$30,500,000	$1,970
18	**15,740**	**$134,300,000**	**$126,200,000**	**$129,870,000**	**$118,000,000**	**$12,521,000**	**$260,400,000**	**$16,600,000**	**$12,500,000**	**$32,000,000**	**$2,030**
19	15,740	$138,400,000	$130,100,000	$137,080,000	$118,000,000	$13,384,000	$268,500,000	$17,100,000	$13,100,000	$33,400,000	$2,130
20	15,740	$142,700,000	$134,100,000	$144,290,000	$118,000,000	$14,381,000	$276,700,000	$17,600,000	$13,800,000	$34,900,000	$2,220

Table 9: Project Cost Summary by AWPF Capacity (with tertiary and MF backwash recycle)

AWPF Capacity (mgd)	AWPF Product Water Yield (95% online) (AFY)	Construction Costs Total ($)	Soft Costs Total ($)	Capital Costs				Annualized Capital Costs Total ($)	Annualized O&M Costs Total ($)	Total Annualized Cost Total ($)	Annual Unit Cost Total ($/AF)
				AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)				
1	1,070	$65,100,000	$61,200,000	$7,220,000	$118,000,000	$1,032,000	$126,300,000	$8,100,000	$1,500,000	$9,600,000	$8,970
2	2,130	$69,200,000	$65,100,000	$14,430,000	$118,000,000	$1,734,000	$134,200,000	$8,600,000	$2,200,000	$10,900,000	$5,140
3	3,210	$73,300,000	$68,900,000	$21,650,000	$118,000,000	$2,386,000	$142,100,000	$9,100,000	$2,800,000	$12,200,000	$3,780
4	4,270	$77,300,000	$72,700,000	$28,860,000	$118,000,000	$2,960,000	$149,900,000	$9,600,000	$3,500,000	$13,400,000	$3,140
5	5,330	$81,300,000	$76,400,000	$36,080,000	$118,000,000	$3,550,000	$157,700,000	$10,000,000	$4,200,000	$14,700,000	$2,760
6	6,400	$85,300,000	$80,200,000	$43,290,000	$118,000,000	$4,128,000	$165,500,000	$10,500,000	$4,800,000	$15,900,000	$2,500
7	7,460	$89,400,000	$84,000,000	$50,510,000	$118,000,000	$4,761,000	$173,300,000	$11,000,000	$5,400,000	$17,200,000	$2,300
8	8,530	$93,400,000	$87,800,000	$57,720,000	$118,000,000	$5,331,000	$181,100,000	$11,500,000	$6,100,000	$18,500,000	$2,170
9	9,590	$97,400,000	$91,600,000	$64,930,000	$118,000,000	$5,973,000	$189,000,000	$12,000,000	$6,700,000	$19,700,000	$2,070
10	10,650	$101,500,000	$95,400,000	$72,150,000	$118,000,000	$6,623,000	$196,800,000	$12,500,000	$7,300,000	$21,000,000	$1,990
11	11,720	$105,500,000	$99,200,000	$79,360,000	$118,000,000	$7,199,000	$204,600,000	$13,000,000	$7,900,000	$22,300,000	$1,910
12	12,780	$109,600,000	$103,000,000	$86,580,000	$118,000,000	$7,954,000	$212,600,000	$13,500,000	$8,600,000	$23,700,000	$1,870
13	13,770	$113,700,000	$106,900,000	$93,790,000	$118,000,000	$8,635,000	$220,500,000	$14,000,000	$9,300,000	$25,000,000	$1,820
14	14,700	**$117,800,000**	**$110,700,000**	**$101,010,000**	**$118,000,000**	**$9,324,000**	**$228,400,000**	**$14,500,000**	**$9,900,000**	**$26,300,000**	$1,800
15	15,510	$121,900,000	$114,600,000	$108,220,000	$118,000,000	$10,125,000	$236,400,000	$15,000,000	$10,600,000	$27,800,000	$1,800
16	16,100	$126,000,000	$118,400,000	$115,440,000	$118,000,000	$10,839,000	$244,300,000	$15,500,000	$11,200,000	$29,100,000	$1,820
17	16,570	$130,100,000	$122,300,000	$122,650,000	$118,000,000	$11,671,000	$252,400,000	$16,100,000	$11,800,000	$30,500,000	$1,850
18	16,990	**$134,300,000**	**$126,200,000**	**$129,870,000**	**$118,000,000**	**$12,521,000**	**$260,400,000**	**$16,600,000**	**$12,500,000**	**$32,000,000**	$1,900
19	17,290	$138,400,000	$130,100,000	$137,080,000	$118,000,000	$13,384,000	$268,500,000	$17,100,000	$13,100,000	$33,400,000	$1,940
20	17,370	$142,700,000	$134,100,000	$144,290,000	$118,000,000	$14,381,000	$276,700,000	$17,600,000	$13,800,000	$34,900,000	$2,030

APPENDIX A

City of San Diego IPR/PMPO

Concept Design Report - Conveyance System

Table: Projected Flows Based on Max Month RW Demands and Fixed AWPF Capacity

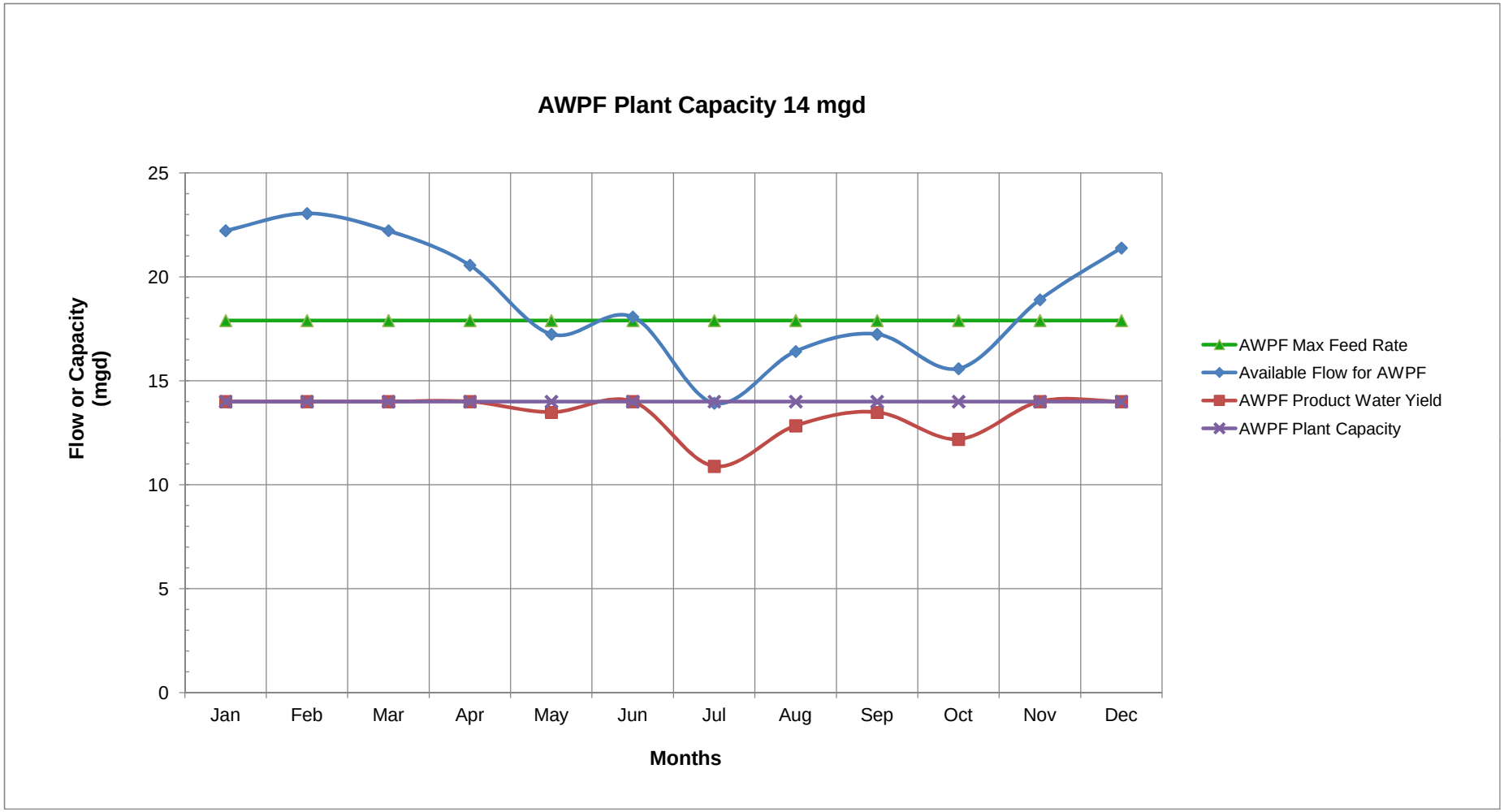
Month	NCWRP Capacity (mgd)	Sludge (mgd)	Available for Tertiary Flow (mgd)	Tertiary Filter Backwash (mgd)	Tertiary Flow Product (mgd)	Utility Water (mgd)	RW Demand by Month (mgd)	Available Flow for AWPF (mgd)	AWPF Feed Rate (mgd)	AWPF Waste Streams (mgd)	AWPF Product Yield (mgd)	Total Flow to PLWWTP (mgd)	AWPF Max Feed Rate (mgd)	Excess RW (mgd)	RW Deficit Capacity (mgd)
Jan	30	1.4	28.6	0.6	28.00	0.80	4.98	22.22	17.90	3.90	14.00	9.62	17.90	4.32	0
Feb	30	1.4	28.6	0.6	28.00	0.80	4.15	23.05	17.90	3.90	14.00	10.45	17.90	5.15	0
Mar	30	1.4	28.6	0.6	28.00	0.80	4.98	22.22	17.90	3.90	14.00	9.62	17.90	4.32	0
Apr	30	1.4	28.6	0.6	28.00	0.80	6.64	20.56	17.90	3.90	14.00	7.96	17.90	2.66	0
May	30	1.4	28.6	**0.6**	28.00	0.80	9.96	17.24	17.24	3.76	13.48	5.16	17.90	0	0.66
Jun	30	1.4	28.6	0.6	28.00	0.80	9.13	18.07	17.90	3.90	14.00	5.47	17.90	0.17	0
Jul	30	1.4	28.6	0.6	28.00	0.80	13.28	13.92	13.92	3.03	10.89	4.43	17.90	0	3.98
Aug	30	1.4	28.6	0.6	28.00	0.80	10.79	16.41	16.41	3.58	12.83	4.98	17.90	0	1.49
Sep	30	1.4	28.6	0.6	28.00	0.80	9.96	17.24	17.24	3.76	13.48	5.16	17.90	0	0.66
Oct	30	1.4	28.6	0.6	28.00	0.80	11.62	15.58	15.58	3.40	12.18	4.80	17.90	0	2.32
Nov	30	1.4	28.6	0.6	28.00	0.80	8.30	18.90	17.90	3.90	14.00	6.30	17.90	1	0.00
Dec	30	1.4	28.6	0.6	28.00	0.80	5.81	21.39	**17.90**	3.90	14.00	8.79	17.90	3.49	0
														21.11	9.11
				Volume (MG/Yr)			3030	6899	6256	1364	4893	2517		633	273
				Volume (AFY)				21,172	19,202	4,186	**15,016**	7,725		1,944	839
				AWPF Annual Offline Percentage	5%				**960**	**209**	**751**	**386**		97	42
				Adjusted Volume (AFY)				21,172	18,241	3,977	14,265	7,339		1,846	797
				Adjusted Avg Annual Flow (mgd)			**8.30**	**18.90**	**16.3**	**3.5**	**12.7**	**6.6**		**1.6**	**0.7**

NCWRF RW Produced	**30 mgd**
Sludge	**1.4 mgd**
Filter Backwash	**0.6 mgd**
MF/RO Waste	**21.8%**
Utility Water	**0.80 mgd**

AWPF Max Feed Rate	**17.90 mgd**

Max	**14.00**
Min	10.89

AWPF Capacity	**14 mgd**


AWPF Plant Capacity 14 mgd
Flow or Capacity (mgd)
25
20
15
10
5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Months
AWPF Max Feed Rate
Available Flow for AWPF
AWPF Product Water Yield
AWPF Plant Capacity

City of San Diego IPR/PMPO
Concept Design Report - Conveyance System

Table: Projected Flows Based on Max Month RW Demands and Fixed AWPF Capacity (EDR Brine to PL)

Month	Raw WW Influent (mgd)	Tertiary Filter Backwash Return (mgd)	MF Backwash Return (mgd)	Total NCWRP Primary/ Secondary Influent (mgd)	Sludge sent to MBC (mgd)	Secondary Effluent (mgd)	Tertiary Filter Backwash (mgd)	Tertiary Product (mgd)	Utility Water (mgd)	EDR Feed (mgd)	EDR Product (Based on demands for RW, UW and TF BW water) (mgd)	EDR Brine (mgd)	RW Demand by Month (mgd)	Available Flow After NPR Demand (mgd)	Projected Flow to AWPF (mgd)	AWPF MF Backwash Water (mgd)	AWPF Brine (mgd)	AWPF Product Water Yield (mgd)	Total Flow to PLWWTP (Brine flows and surplus water)	AWPF Max Feed Rate (mgd)	Surplus Water after NPR and AWPF Demands (mgd)	AWPF Capacity Not Used (mgd)
Jan	30	0.6	1.61	32.21	1.4	30.81	0.6	30.21	0.80	2.48	2.11	0.37	4.98	24.06	23.00	1.61	3.2	18.2	4.88	23.00	1.06	0
Feb	30	0.6	1.61	32.21	1.4	30.81	0.6	30.21	0.80	2.15	1.83	0.32	4.15	24.94	23.00	1.61	3.2	18.2	5.71	23.00	1.94	0
Mar	30	0.6	1.61	32.21	1.4	30.81	0.6	30.21	0.80	2.48	2.11	0.37	4.98	24.06	23.00	1.61	3.2	18.2	4.88	23.00	1.06	0
Apr	30	0.6	1.56	32.16	1.4	30.76	0.6	30.16	0.80	3.12	2.65	0.47	6.64	22.25	22.26	1.56	3.1	17.6	3.81	23.00	0	0.75
May	30	0.6	1.29	31.89	1.4	30.49	0.6	29.89	0.80	4.41	3.75	0.66	9.96	18.47	18.48	1.29	2.6	14.6	3.43	23.00	0	4.53
Jun	30	0.6	1.36	31.96	1.4	30.56	0.6	29.96	0.80	4.09	3.47	0.61	9.13	19.42	19.42	1.36	2.7	15.4	3.53	23.00	0	3.58
Jul	30	0.6	1.03	31.63	1.4	30.23	0.6	29.63	0.80	5.70	4.84	0.85	13.28	14.69	14.70	1.03	2.1	11.6	3.06	23.00	0	8.31
Aug	30	0.6	1.23	31.83	1.4	30.43	0.6	29.83	0.80	4.73	4.02	0.71	10.79	17.53	17.53	1.23	2.4	13.9	3.34	23.00	0	5.47
Sep	30	0.6	1.29	31.89	1.4	30.49	0.6	29.89	0.80	4.41	3.75	0.66	9.96	18.47	18.48	1.29	2.6	14.6	3.43	23.00	0	4.53
Oct	30	0.6	1.16	31.76	1.4	30.36	0.6	29.76	0.80	5.05	4.30	0.76	11.62	16.58	16.59	1.16	2.3	13.1	3.25	23.00	0	6.42
Nov	30	0.6	1.43	32.03	1.4	30.63	0.6	30.03	0.80	3.77	3.20	0.56	8.30	20.36	20.36	1.43	2.8	16.1	3.62	23.00	0	2.64
Dec	30	0.6	1.61	32.21	1.4	30.81	0.6	30.21	0.80	2.80	2.38	0.42	5.81	23.18	23.00	1.61	3.2	18.2	4.05	23.00	0.18	0
																					4.23	36.23
Annual Volume (MG)								10950										5766			129	1102
Annual Volume (AF)								33,605										17,697			395	3,382
AWPF Annual Offline Percentage							5%											885			20	169
Adjusted Annual Volume (AF)																		16,813			375	3,213
Adjusted Avg Annual AWPF Product Water Yield (mgd)								30.00										**15.01**			**0.34**	**2.87**
																					122.340199	

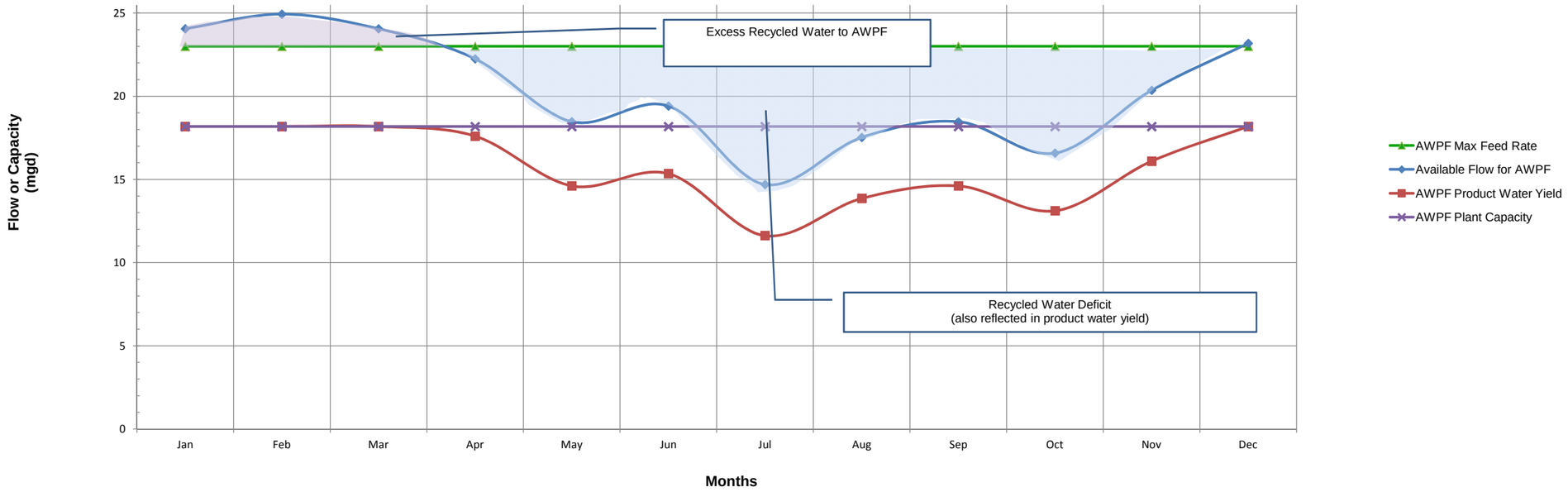
Annual Volume (MG)
Annual Volume (AF)
AWPF Annual Offline Percentage
Adjusted Annual Volume (AF)
Adjusted Avg Annual RW Flows (mgd)

	NCWRF RW Produced	**30 mgd**	
1.57500	Sludge	**1.4 mgd**	
0.07	Filter Backwash (Recycled)	**0.6 mgd**	
	RO Waste	**15%**	
	MF Backwash Recycled	**7.0%**	
	Utility Water (excludes 0.5 mgd irr wtr)	**0.80 mgd**	

Max Monthly Yield	18.2	
Min Monthly Yield	11.6	

AWPF Max Feed Rate	**23.0 mgd**	
	AWPF Capacity	**18 mgd**

AWPF Plant Capacity 18 mgd
Max Feed Rate 23 mgd
Avg Annual Product Water Yield 16,847 AFY



APPENDIX B

APPENDIX B

City of San Diego WPDP

Detailed Cost Breakdown of Project Costs
(Constant 30-inch Conveyance Pipe)

AWPF Capacity (mgd)	Estimated AWPF Product Water Yield (AFY)	AWPF Product Wtr Yield, 95% On-line (AFY)	Adjusted Pipe Dia (in)	Pump Flow Rate (gpm)	Pump TDH (ft)	Pump Power (Hp)	Construction Costs				Soft Costs			
							AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)	AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)
1	1,120	1,070	30	700	450	110	$3,719,000	$60,840,000	$532,000	$65,100,000	$3,495,860	$57,189,600	$500,080	$61,200,000
2	2,240	2,130	30	1,400	450	220	$7,438,000	$60,840,000	$894,000	$69,200,000	$6,991,720	$57,189,600	$840,360	$65,100,000
3	3,370	3,210	30	2,100	460	330	$11,156,000	$60,840,000	$1,230,000	$73,300,000	$10,486,640	$57,189,600	$1,156,200	$68,900,000
4	4,490	4,270	30	2,800	460	440	$14,875,000	$60,840,000	$1,526,000	$77,300,000	$13,982,500	$57,189,600	$1,434,440	$72,700,000
5	5,610	5,330	30	3,500	470	560	$18,594,000	$60,840,000	$1,830,000	$81,300,000	$17,478,360	$57,189,600	$1,720,200	$76,400,000
6	6,730	6,400	30	4,200	480	680	$22,313,000	$60,840,000	$2,128,000	$85,300,000	$20,974,220	$57,189,600	$2,000,320	$80,200,000
7	7,850	7,460	30	4,900	500	830	$26,032,000	$60,840,000	$2,454,000	$89,400,000	$24,470,080	$57,189,600	$2,306,760	$84,000,000
8	8,970	8,530	30	5,600	510	970	$29,751,000	$60,840,000	$2,748,000	$93,400,000	$27,965,940	$57,189,600	$2,583,120	$87,800,000
9	10,090	9,590	30	6,300	530	1,130	$33,469,000	$60,840,000	$3,079,000	$97,400,000	$31,460,860	$57,189,600	$2,894,260	$91,600,000
10	11,210	10,650	30	7,000	550	1,300	$37,188,000	$60,840,000	$3,414,000	$101,500,000	$34,956,720	$57,189,600	$3,209,160	$95,400,000
11	12,320	11,710	30	7,700	560	1,460	$40,907,000	$60,840,000	$3,711,000	$105,500,000	$38,452,580	$57,189,600	$3,488,340	$99,200,000
12	13,340	12,680	30	8,400	590	1,670	$44,626,000	$60,840,000	$4,100,000	$109,600,000	$41,948,440	$57,189,600	$3,854,000	$103,000,000
13	14,280	13,570	30	9,100	610	1,870	$48,345,000	$60,840,000	$4,451,000	$113,700,000	$45,444,300	$57,189,600	$4,183,940	$106,900,000
14	15,020	14,270	30	9,800	630	2,080	$52,064,000	$60,840,000	$4,806,000	$117,800,000	$48,940,160	$57,189,600	$4,517,640	$110,700,000
15	15,570	14,800	30	10,500	660	2,340	$55,782,000	$60,840,000	$5,219,000	$121,900,000	$52,435,080	$57,189,600	$4,905,860	$114,600,000
16	16,040	15,240	30	11,200	680	2,570	$59,501,000	$60,840,000	$5,587,000	$126,000,000	$55,930,940	$57,189,600	$5,251,780	$118,400,000
17	16,400	15,580	30	11,900	710	2,850	$63,220,000	$60,840,000	$6,016,000	$130,100,000	$59,426,800	$57,189,600	$5,655,040	$122,300,000
18	16,560	15,740	30	12,500	740	3,120	$66,939,000	$60,840,000	$6,454,000	$134,300,000	$62,922,660	$57,189,600	$6,066,760	$126,200,000
19	16,560	15,740	30	13,200	770	3,430	$70,658,000	$60,840,000	$6,899,000	$138,400,000	$66,418,520	$57,189,600	$6,485,060	$130,100,000
20	16,560	15,740	30	13,900	810	3,800	$74,376,000	$60,840,000	$7,413,000	$142,700,000	$69,913,440	$57,189,600	$6,968,220	$134,100,000

APPENDIX B

City of San Diego WPDP

Detailed Cost Breakdown of Project Costs
(Constant 30-inch Conveyance Pipe)

AWPF Capacity (mgd)	Estimated AWPF Product Water Yield (AFY)	AWPF Product Wtr Yield, 95% On-line (AFY)	Adjusted Pipe Dia (in)	Pump Flow Rate (gpm)	Pump TDH (ft)	Capital Costs				Annualized Capital Costs			
						AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)	AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)
1	1,120	1,070	30	700	450	$7,220,000	$118,000,000	$1,032,000	$126,300,000	$458,000	$7,486,000	$65,000	$8,100,000
2	2,240	2,130	30	1,400	450	$14,430,000	$118,000,000	$1,734,000	$134,200,000	$916,000	$7,486,000	$110,000	$8,600,000
3	3,370	3,210	30	2,100	460	$21,650,000	$118,000,000	$2,386,000	$142,100,000	$1,374,000	$7,486,000	$151,000	$9,100,000
4	4,490	4,270	30	2,800	460	$28,860,000	$118,000,000	$2,960,000	$149,900,000	$1,831,000	$7,486,000	$188,000	$9,600,000
5	5,610	5,330	30	3,500	470	$36,080,000	$118,000,000	$3,550,000	$157,700,000	$2,289,000	$7,486,000	$225,000	$10,000,000
6	6,730	6,400	30	4,200	480	$43,290,000	$118,000,000	$4,128,000	$165,500,000	$2,747,000	$7,486,000	$262,000	$10,500,000
7	7,850	7,460	30	4,900	500	$50,510,000	$118,000,000	$4,761,000	$173,300,000	$3,205,000	$7,486,000	$302,000	$11,000,000
8	8,970	8,530	30	5,600	510	$57,720,000	$118,000,000	$5,331,000	$181,100,000	$3,662,000	$7,486,000	$338,000	$11,500,000
9	10,090	9,590	30	6,300	530	$64,930,000	$118,000,000	$5,973,000	$189,000,000	$4,119,000	$7,486,000	$379,000	$12,000,000
10	11,210	10,650	30	7,000	550	$72,150,000	$118,000,000	$6,623,000	$196,800,000	$4,578,000	$7,486,000	$420,000	$12,500,000
11	12,320	11,710	30	7,700	560	$79,360,000	$118,000,000	$7,199,000	$204,600,000	$5,035,000	$7,486,000	$457,000	$13,000,000
12	13,340	12,680	30	8,400	590	$86,580,000	$118,000,000	$7,954,000	$212,600,000	$5,493,000	$7,486,000	$505,000	$13,500,000
13	14,280	13,570	30	9,100	610	$93,790,000	$118,000,000	$8,635,000	$220,500,000	$5,950,000	$7,486,000	$548,000	$14,000,000
14	15,020	14,270	30	9,800	630	$101,010,000	$118,000,000	$9,324,000	$228,400,000	$6,409,000	$7,486,000	$592,000	$14,500,000
15	15,570	14,800	30	10,500	660	$108,220,000	$118,000,000	$10,125,000	$236,400,000	$6,866,000	$7,486,000	$642,000	$15,000,000
16	16,040	15,240	30	11,200	680	$115,440,000	$118,000,000	$10,839,000	$244,300,000	$7,324,000	$7,486,000	$688,000	$15,500,000
17	16,400	15,580	30	11,900	710	$122,650,000	$118,000,000	$11,671,000	$252,400,000	$7,781,000	$7,486,000	$740,000	$16,100,000
18	16,560	15,740	30	12,500	740	$129,870,000	$118,000,000	$12,521,000	$260,400,000	$8,240,000	$7,486,000	$794,000	$16,600,000
19	16,560	15,740	30	13,200	770	$137,080,000	$118,000,000	$13,384,000	$268,500,000	$8,697,000	$7,486,000	$849,000	$17,100,000
20	16,560	15,740	30	13,900	810	$144,290,000	$118,000,000	$14,381,000	$276,700,000	$9,154,000	$7,486,000	$912,000	$17,600,000

APPENDIX B

City of San Diego WPDP

Detailed Cost Breakdown of Project Costs
(Constant 30-inch Conveyance Pipe)

AWPF Capacity (mgd)	Estimated AWPF Product Water Yield (AFY)	AWPF Product Wtr Yield, 95% On-line (AFY)	Adjusted Pipe Dia (in)	Pump Flow Rate (gpm)	Pump TDH (ft)	Annualized O&M Costs				Total Annualized Cost			
						AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)	AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)
1	1,120	1,070	30	700	450	$600,000	$851,760	$18,620	$1,500,000	$1,058,000	$8,337,760	$186,070	$9,600,000
2	2,240	2,130	30	1,400	450	$1,300,000	$851,760	$31,290	$2,200,000	$2,216,000	$8,337,760	$346,040	$10,900,000
3	3,370	3,210	30	2,100	460	$1,900,000	$851,760	$43,050	$2,800,000	$3,274,000	$8,337,760	$501,250	$12,200,000
4	4,490	4,270	30	2,800	460	$2,500,000	$851,760	$53,410	$3,500,000	$4,331,000	$8,337,760	$650,910	$13,400,000
5	5,610	5,330	30	3,500	470	$3,200,000	$851,760	$64,050	$4,200,000	$5,489,000	$8,337,760	$810,300	$14,700,000
6	6,730	6,400	30	4,200	480	$3,800,000	$851,760	$74,480	$4,800,000	$6,547,000	$8,337,760	$969,330	$15,900,000
7	7,850	7,460	30	4,900	500	$4,400,000	$851,760	$85,890	$5,400,000	$7,605,000	$8,337,760	$1,160,390	$17,200,000
8	8,970	8,530	30	5,600	510	$5,100,000	$851,760	$96,180	$6,100,000	$8,762,000	$8,337,760	$1,337,030	$18,500,000
9	10,090	9,590	30	6,300	530	$5,700,000	$851,760	$107,765	$6,700,000	$9,819,000	$8,337,760	$1,538,565	$19,700,000
10	11,210	10,650	30	7,000	550	$6,300,000	$851,760	$119,490	$7,300,000	$10,878,000	$8,337,760	$1,749,390	$21,000,000
11	12,320	11,710	30	7,700	560	$6,900,000	$851,760	$129,885	$7,900,000	$11,935,000	$8,337,760	$1,945,735	$22,300,000
12	13,340	12,680	30	8,400	590	$7,600,000	$851,760	$143,500	$8,600,000	$13,093,000	$8,337,760	$2,202,800	$23,700,000
13	14,280	13,570	30	9,100	610	$8,200,000	$851,760	$155,785	$9,300,000	$14,150,000	$8,337,760	$2,444,235	$25,000,000
14	15,020	14,270	30	9,800	630	$8,800,000	$851,760	$168,210	$9,900,000	$15,209,000	$8,337,760	$2,696,110	$26,300,000
15	15,570	14,800	30	10,500	660	$9,500,000	$851,760	$182,665	$10,600,000	$16,366,000	$8,337,760	$3,002,515	$27,800,000
16	16,040	15,240	30	11,200	680	$10,100,000	$851,760	$195,545	$11,200,000	$17,424,000	$8,337,760	$3,275,595	$29,100,000
17	16,400	15,580	30	11,900	710	$10,700,000	$851,760	$210,560	$11,800,000	$18,481,000	$8,337,760	$3,603,160	$30,500,000
18	16,560	15,740	30	12,500	740	$11,400,000	$851,760	$225,890	$12,500,000	$19,640,000	$8,337,760	$3,923,740	$32,000,000
19	16,560	15,740	30	13,200	770	$12,000,000	$851,760	$241,465	$13,100,000	$20,697,000	$8,337,760	$4,282,915	$33,400,000
20	16,560	15,740	30	13,900	810	$12,600,000	$851,760	$259,455	$13,800,000	$21,754,000	$8,337,760	$4,708,305	$34,900,000

APPENDIX B

City of San Diego WPDP

Detailed Cost Breakdown of Project Costs
(Constant 30-inch Conveyance Pipe)

AWPF Capacity (mgd)	Estimated AWPF Product Water Yield (AFY)	AWPF Product Wtr Yield, 95% On-line (AFY)	Adjusted Pipe Dia (in)	Pump Flow Rate (gpm)	Pump TDH (ft)	Annual Unit Cost			
						AWPF ($/AF)	Pipeline ($/AF)	Pump Station ($/AF)	Total ($/AF)
1	1,120	1,070	30	700	450	$990	$7,800	$180	$8,970
2	2,240	2,130	30	1,400	450	$1,050	$3,920	$170	$5,140
3	3,370	3,210	30	2,100	460	$1,020	$2,600	$160	$3,780
4	4,490	4,270	30	2,800	460	$1,020	$1,960	$160	$3,140
5	5,610	5,330	30	3,500	470	$1,030	$1,570	$160	$2,760
6	6,730	6,400	30	4,200	480	$1,030	$1,310	$160	$2,500
7	7,850	7,460	30	4,900	500	$1,020	$1,120	$160	$2,300
8	8,970	8,530	30	5,600	510	$1,030	$980	$160	$2,170
9	10,090	9,590	30	6,300	530	$1,030	$870	$170	$2,070
10	11,210	10,650	30	7,000	550	$1,030	$790	$170	$1,990
11	12,320	11,710	30	7,700	560	$1,020	$720	$170	$1,910
12	13,340	12,680	30	8,400	590	$1,040	$660	$180	$1,880
13	14,280	13,570	30	9,100	610	$1,050	$620	$190	$1,860
14	15,020	14,270	30	9,800	630	$1,070	$590	$190	$1,850
15	15,570	14,800	30	10,500	660	$1,110	$570	$210	$1,890
16	16,040	15,240	30	11,200	680	$1,150	$550	$220	$1,920
17	16,400	15,580	30	11,900	710	$1,190	$540	$240	$1,970
18	16,560	15,740	30	12,500	740	$1,250	$530	$250	$2,030
19	16,560	15,740	30	13,200	770	$1,320	$530	$280	$2,130
20	16,560	15,740	30	13,900	810	$1,390	$530	$300	$2,220

APPENDIX B

City of San Diego WPDP

Detailed Cost Breakdown of Project Costs
(Constant 30-inch Conveyance Pipe)
(with tertiary and MF backwash recycle)

AWPF Capacity (mgd)	Estimated AWPF Product Water Yield (AFY)	AWPF Product Wtr Yield, 95% On-line (AFY)	Adjusted Pipe Dia (in)	Pump Flow Rate (gpm)	Pump TDH (ft)	Pump Power (Hp)	Construction Costs				Soft Costs			
							AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)	AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)
1	1,120	1,070	30	700	450	110	$3,719,000	$60,840,000	$532,000	$65,100,000	$3,495,860	$57,189,600	$500,080	$61,200,000
2	2,240	2,130	30	1,400	450	220	$7,438,000	$60,840,000	$894,000	$69,200,000	$6,991,720	$57,189,600	$840,360	$65,100,000
3	3,370	3,210	30	2,100	460	330	$11,156,000	$60,840,000	$1,230,000	$73,300,000	$10,486,640	$57,189,600	$1,156,200	$68,900,000
4	4,490	4,270	30	2,800	460	440	$14,875,000	$60,840,000	$1,526,000	$77,300,000	$13,982,500	$57,189,600	$1,434,440	$72,700,000
5	5,610	5,330	30	3,500	470	560	$18,594,000	$60,840,000	$1,830,000	$81,300,000	$17,478,360	$57,189,600	$1,720,200	$76,400,000
6	6,730	6,400	30	4,200	480	680	$22,313,000	$60,840,000	$2,128,000	$85,300,000	$20,974,220	$57,189,600	$2,000,320	$80,200,000
7	7,850	7,460	30	4,900	500	830	$26,032,000	$60,840,000	$2,454,000	$89,400,000	$24,470,080	$57,189,600	$2,306,760	$84,000,000
8	8,970	8,530	30	5,600	510	970	$29,751,000	$60,840,000	$2,748,000	$93,400,000	$27,965,940	$57,189,600	$2,583,120	$87,800,000
9	10,090	9,590	30	6,300	530	1,130	$33,469,000	$60,840,000	$3,079,000	$97,400,000	$31,460,860	$57,189,600	$2,894,260	$91,600,000
10	11,210	10,650	30	7,000	550	1,300	$37,188,000	$60,840,000	$3,414,000	$101,500,000	$34,956,720	$57,189,600	$3,209,160	$95,400,000
11	12,330	11,720	30	7,700	560	1,460	$40,907,000	$60,840,000	$3,711,000	$105,500,000	$38,452,580	$57,189,600	$3,488,340	$99,200,000
12	13,450	12,780	30	8,400	590	1,670	$44,626,000	$60,840,000	$4,100,000	$109,600,000	$41,948,440	$57,189,600	$3,854,000	$103,000,000
13	14,490	13,770	30	9,100	610	1,870	$48,345,000	$60,840,000	$4,451,000	$113,700,000	$45,444,300	$57,189,600	$4,183,940	$106,900,000
14	15,470	14,700	30	9,800	630	2,080	$52,064,000	$60,840,000	$4,806,000	$117,800,000	$48,940,160	$57,189,600	$4,517,640	$110,700,000
15	16,320	15,510	30	10,500	660	2,340	$55,782,000	$60,840,000	$5,219,000	$121,900,000	$52,435,080	$57,189,600	$4,905,860	$114,600,000
16	16,940	16,100	30	11,200	680	2,570	$59,501,000	$60,840,000	$5,587,000	$126,000,000	$55,930,940	$57,189,600	$5,251,780	$118,400,000
17	17,440	16,570	30	11,900	710	2,850	$63,220,000	$60,840,000	$6,016,000	$130,100,000	$59,426,800	$57,189,600	$5,655,040	$122,300,000
18	17,880	16,990	30	12,500	740	3,120	$66,939,000	$60,840,000	$6,454,000	$134,300,000	$62,922,660	$57,189,600	$6,066,760	$126,200,000
19	18,190	17,290	30	13,200	770	3,430	$70,658,000	$60,840,000	$6,899,000	$138,400,000	$66,418,520	$57,189,600	$6,485,060	$130,100,000
20	18,280	17,370	30	13,900	810	3,800	$74,376,000	$60,840,000	$7,413,000	$142,700,000	$69,913,440	$57,189,600	$6,968,220	$134,100,000

APPENDIX B

City of San Diego WPDP

Detailed Cost Breakdown of Project Costs
(Constant 30-inch Conveyance Pipe)
(with tertiary and MF backwash recycle)

AWPF Capacity (mgd)	Estimated AWPF Product Water Yield (AFY)	AWPF Product Wtr Yield, 95% On-line (AFY)	Adjusted Pipe Dia (in)	Pump Flow Rate (gpm)	Pump TDH (ft)	Capital Costs				Annualized Capital Costs			
						AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)	AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)
1	1,120	1,070	30	700	450	$7,220,000	$118,000,000	$1,032,000	$126,300,000	$458,000	$7,486,000	$65,000	$8,100,000
2	2,240	2,130	30	1,400	450	$14,430,000	$118,000,000	$1,734,000	$134,200,000	$916,000	$7,486,000	$110,000	$8,600,000
3	3,370	3,210	30	2,100	460	$21,650,000	$118,000,000	$2,386,000	$142,100,000	$1,374,000	$7,486,000	$151,000	$9,100,000
4	4,490	4,270	30	2,800	460	$28,860,000	$118,000,000	$2,960,000	$149,900,000	$1,831,000	$7,486,000	$188,000	$9,600,000
5	5,610	5,330	30	3,500	470	$36,080,000	$118,000,000	$3,550,000	$157,700,000	$2,289,000	$7,486,000	$225,000	$10,000,000
6	6,730	6,400	30	4,200	480	$43,290,000	$118,000,000	$4,128,000	$165,500,000	$2,747,000	$7,486,000	$262,000	$10,500,000
7	7,850	7,460	30	4,900	500	$50,510,000	$118,000,000	$4,761,000	$173,300,000	$3,205,000	$7,486,000	$302,000	$11,000,000
8	8,970	8,530	30	5,600	510	$57,720,000	$118,000,000	$5,331,000	$181,100,000	$3,662,000	$7,486,000	$338,000	$11,500,000
9	10,090	9,590	30	6,300	530	$64,930,000	$118,000,000	$5,973,000	$189,000,000	$4,119,000	$7,486,000	$379,000	$12,000,000
10	11,210	10,650	30	7,000	550	$72,150,000	$118,000,000	$6,623,000	$196,800,000	$4,578,000	$7,486,000	$420,000	$12,500,000
11	12,330	11,720	30	7,700	560	$79,360,000	$118,000,000	$7,199,000	$204,600,000	$5,035,000	$7,486,000	$457,000	$13,000,000
12	13,450	12,780	30	8,400	590	$86,580,000	$118,000,000	$7,954,000	$212,600,000	$5,493,000	$7,486,000	$505,000	$13,500,000
13	14,490	13,770	30	9,100	610	$93,790,000	$118,000,000	$8,635,000	$220,500,000	$5,950,000	$7,486,000	$548,000	$14,000,000
14	15,470	14,700	30	9,800	630	$101,010,000	$118,000,000	$9,324,000	$228,400,000	$6,409,000	$7,486,000	$592,000	$14,500,000
15	16,320	15,510	30	10,500	660	$108,220,000	$118,000,000	$10,125,000	$236,400,000	$6,866,000	$7,486,000	$642,000	$15,000,000
16	16,940	16,100	30	11,200	680	$115,440,000	$118,000,000	$10,839,000	$244,300,000	$7,324,000	$7,486,000	$688,000	$15,500,000
17	17,440	16,570	30	11,900	710	$122,650,000	$118,000,000	$11,671,000	$252,400,000	$7,781,000	$7,486,000	$740,000	$16,100,000
18	17,880	16,990	30	12,500	740	$129,870,000	$118,000,000	$12,521,000	$260,400,000	$8,240,000	$7,486,000	$794,000	$16,600,000
19	18,190	17,290	30	13,200	770	$137,080,000	$118,000,000	$13,384,000	$268,500,000	$8,697,000	$7,486,000	$849,000	$17,100,000
20	18,280	17,370	30	13,900	810	$144,290,000	$118,000,000	$14,381,000	$276,700,000	$9,154,000	$7,486,000	$912,000	$17,600,000

APPENDIX B

City of San Diego WPDP

Detailed Cost Breakdown of Project Costs
(Constant 30-inch Conveyance Pipe)
(with tertiary and MF backwash recycle)

AWPF Capacity (mgd)	Estimated AWPF Product Water Yield (AFY)	AWPF Product Wtr Yield, 95% On-line (AFY)	Adjusted Pipe Dia (in)	Pump Flow Rate (gpm)	Pump TDH (ft)	Annualized O&M Costs				Total Annualized Cost			
						AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)	AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)
1	1,120	1,070	30	700	450	$600,000	$851,760	$18,620	$1,500,000	$1,058,000	$8,337,760	$186,070	$9,600,000
2	2,240	2,130	30	1,400	450	$1,300,000	$851,760	$31,290	$2,200,000	$2,216,000	$8,337,760	$346,040	$10,900,000
3	3,370	3,210	30	2,100	460	$1,900,000	$851,760	$43,050	$2,800,000	$3,274,000	$8,337,760	$501,250	$12,200,000
4	4,490	4,270	30	2,800	460	$2,500,000	$851,760	$53,410	$3,500,000	$4,331,000	$8,337,760	$650,910	$13,400,000
5	5,610	5,330	30	3,500	470	$3,200,000	$851,760	$64,050	$4,200,000	$5,489,000	$8,337,760	$810,300	$14,700,000
6	6,730	6,400	30	4,200	480	$3,800,000	$851,760	$74,480	$4,800,000	$6,547,000	$8,337,760	$969,330	$15,900,000
7	7,850	7,460	30	4,900	500	$4,400,000	$851,760	$85,890	$5,400,000	$7,605,000	$8,337,760	$1,160,390	$17,200,000
8	8,970	8,530	30	5,600	510	$5,100,000	$851,760	$96,180	$6,100,000	$8,762,000	$8,337,760	$1,337,030	$18,500,000
9	10,090	9,590	30	6,300	530	$5,700,000	$851,760	$107,765	$6,700,000	$9,819,000	$8,337,760	$1,538,565	$19,700,000
10	11,210	10,650	30	7,000	550	$6,300,000	$851,760	$119,490	$7,300,000	$10,878,000	$8,337,760	$1,749,390	$21,000,000
11	12,330	11,720	30	7,700	560	$6,900,000	$851,760	$129,885	$7,900,000	$11,935,000	$8,337,760	$1,945,735	$22,300,000
12	13,450	12,780	30	8,400	590	$7,600,000	$851,760	$143,500	$8,600,000	$13,093,000	$8,337,760	$2,202,800	$23,700,000
13	14,490	13,770	30	9,100	610	$8,200,000	$851,760	$155,785	$9,300,000	$14,150,000	$8,337,760	$2,444,235	$25,000,000
14	15,470	14,700	30	9,800	630	$8,800,000	$851,760	$168,210	$9,900,000	$15,209,000	$8,337,760	$2,696,110	$26,300,000
15	16,320	15,510	30	10,500	660	$9,500,000	$851,760	$182,665	$10,600,000	$16,366,000	$8,337,760	$3,002,515	$27,800,000
16	16,940	16,100	30	11,200	680	$10,100,000	$851,760	$195,545	$11,200,000	$17,424,000	$8,337,760	$3,275,595	$29,100,000
17	17,440	16,570	30	11,900	710	$10,700,000	$851,760	$210,560	$11,800,000	$18,481,000	$8,337,760	$3,603,160	$30,500,000
18	17,880	16,990	30	12,500	740	$11,400,000	$851,760	$225,890	$12,500,000	$19,640,000	$8,337,760	$3,923,740	$32,000,000
19	18,190	17,290	30	13,200	770	$12,000,000	$851,760	$241,465	$13,100,000	$20,697,000	$8,337,760	$4,282,915	$33,400,000
20	18,280	17,370	30	13,900	810	$12,600,000	$851,760	$259,455	$13,800,000	$21,754,000	$8,337,760	$4,708,305	$34,900,000

APPENDIX B

City of San Diego WPDP

Detailed Cost Breakdown of Project Costs
(Constant 30-inch Conveyance Pipe)
(with tertiary and MF backwash recycle)

AWPF Capacity (mgd)	Estimated AWPF Product Water Yield (AFY)	AWPF Product Wtr Yield, 95% On-line (AFY)	Adjusted Pipe Dia (in)	Pump Flow Rate (gpm)	Pump TDH (ft)	Annual Unit Cost			
						AWPF ($/AF)	Pipeline ($/AF)	Pump Station ($/AF)	Total ($/AF)
1	1,120	1,070	30	700	450	$990	$7,800	$180	$8,970
2	2,240	2,130	30	1,400	450	$1,050	$3,920	$170	$5,140
3	3,370	3,210	30	2,100	460	$1,020	$2,600	$160	$3,780
4	4,490	4,270	30	2,800	460	$1,020	$1,960	$160	$3,140
5	5,610	5,330	30	3,500	470	$1,030	$1,570	$160	$2,760
6	6,730	6,400	30	4,200	480	$1,030	$1,310	$160	$2,500
7	7,850	7,460	30	4,900	500	$1,020	$1,120	$160	$2,300
8	8,970	8,530	30	5,600	510	$1,030	$980	$160	$2,170
9	10,090	9,590	30	6,300	530	$1,030	$870	$170	$2,070
10	11,210	10,650	30	7,000	550	$1,030	$790	$170	$1,990
11	12,330	11,720	30	7,700	560	$1,020	$720	$170	$1,910
12	13,450	12,780	30	8,400	590	$1,030	$660	$180	$1,870
13	14,490	13,770	30	9,100	610	$1,030	$610	$180	$1,820
14	15,470	14,700	30	9,800	630	$1,040	$570	$190	$1,800
15	16,320	15,510	30	10,500	660	$1,060	$540	$200	$1,800
16	16,940	16,100	30	11,200	680	$1,090	$520	$210	$1,820
17	17,440	16,570	30	11,900	710	$1,120	$510	$220	$1,850
18	17,880	16,990	30	12,500	740	$1,160	$500	$240	$1,900
19	18,190	17,290	30	13,200	770	$1,200	$490	$250	$1,940
20	18,280	17,370	30	13,900	810	$1,260	$490	$280	$2,030

APPENDIX C

APPENDIX C

City of San Diego WPDP

Detailed Cost Breakdown of Project Costs
(Constant 36-inch Conveyance Pipe)

AWPF Capacity (mgd)	Estimated AWPF Product Water Yield (AFY)	AWPF Product Wtr Yield, 95% On-line (AFY)	Adjusted Pipe Dia (in)	Pump Flow Rate (gpm)	Pump TDH (ft)	Pump Power (Hp)	Construction Costs				Soft Costs			
							AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)	AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)
1	1,120	1,070	36	700	450	110	$3,719,000	$73,008,000	$532,000	$77,300,000	$3,495,860	$68,627,520	$500,080	$72,700,000
2	2,240	2,130	36	1,400	450	220	$7,438,000	$73,008,000	$894,000	$81,400,000	$6,991,720	$68,627,520	$840,360	$76,500,000
3	3,370	3,210	36	2,100	450	320	$11,156,000	$73,008,000	$1,212,000	$85,400,000	$10,486,640	$68,627,520	$1,139,280	$80,300,000
4	4,490	4,270	36	2,800	450	430	$14,875,000	$73,008,000	$1,504,000	$89,400,000	$13,982,500	$68,627,520	$1,413,760	$84,100,000
5	5,610	5,330	36	3,500	460	550	$18,594,000	$73,008,000	$1,804,000	$93,500,000	$17,478,360	$68,627,520	$1,695,760	$87,900,000
6	6,730	6,400	36	4,200	460	660	$22,313,000	$73,008,000	$2,069,000	$97,400,000	$20,974,220	$68,627,520	$1,944,860	$91,600,000
7	7,850	7,460	36	4,900	470	780	$26,032,000	$73,008,000	$2,355,000	$101,400,000	$24,470,080	$68,627,520	$2,213,700	$95,400,000
8	8,970	8,530	36	5,600	470	890	$29,751,000	$73,008,000	$2,603,000	$105,400,000	$27,965,940	$68,627,520	$2,446,820	$99,100,000
9	10,090	9,590	36	6,300	480	1,020	$33,469,000	$73,008,000	$2,884,000	$109,400,000	$31,460,860	$68,627,520	$2,710,960	$102,800,000
10	11,210	10,650	36	7,000	490	1,160	$37,188,000	$73,008,000	$3,164,000	$113,400,000	$34,956,720	$68,627,520	$2,974,160	$106,600,000
11	12,320	11,710	36	7,700	490	1,280	$40,907,000	$73,008,000	$3,398,000	$117,400,000	$38,452,580	$68,627,520	$3,194,120	$110,300,000
12	13,340	12,680	36	8,400	500	1,420	$44,626,000	$73,008,000	$3,676,000	$121,400,000	$41,948,440	$68,627,520	$3,455,440	$114,100,000
13	14,280	13,570	36	9,100	510	1,570	$48,345,000	$73,008,000	$3,955,000	$125,400,000	$45,444,300	$68,627,520	$3,717,700	$117,800,000
14	15,020	14,270	36	9,800	520	1,720	$52,064,000	$73,008,000	$4,235,000	$129,400,000	$48,940,160	$68,627,520	$3,980,900	$121,600,000
15	15,570	14,800	36	10,500	530	1,880	$55,782,000	$73,008,000	$4,516,000	$133,400,000	$52,435,080	$68,627,520	$4,245,040	$125,400,000
16	16,040	15,240	36	11,200	540	2,040	$59,501,000	$73,008,000	$4,799,000	$137,400,000	$55,930,940	$68,627,520	$4,511,060	$129,100,000
17	16,400	15,580	36	11,900	560	2,250	$63,220,000	$73,008,000	$5,144,000	$141,400,000	$59,426,800	$68,627,520	$4,835,360	$132,900,000
18	16,560	15,740	36	12,500	570	2,400	$66,939,000	$73,008,000	$5,432,000	$145,400,000	$62,922,660	$68,627,520	$5,106,080	$136,700,000
19	16,560	15,740	36	13,200	580	2,580	$70,658,000	$73,008,000	$5,722,000	$149,400,000	$66,418,520	$68,627,520	$5,378,680	$140,500,000
20	16,560	15,740	36	13,900	590	2,770	$74,376,000	$73,008,000	$6,014,000	$153,400,000	$69,913,440	$68,627,520	$5,653,160	$144,200,000

APPENDIX C

City of San Diego WPDP

Detailed Cost Breakdown of Project Costs
(Constant 36-inch Conveyance Pipe)

AWPF Capacity (mgd)	Estimated AWPF Product Water Yield (AFY)	AWPF Product Wtr Yield, 95% On-line (AFY)	Adjusted Pipe Dia (in)	Pump Flow Rate (gpm)	Pump TDH (ft)	Capital Costs				Annualized Capital Costs			
						AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)	AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)
1	1,120	1,070	36	700	450	$7,220,000	$141,600,000	$1,032,000	$149,900,000	$458,000	$8,984,000	$65,000	$9,600,000
2	2,240	2,130	36	1,400	450	$14,430,000	$141,600,000	$1,734,000	$157,800,000	$916,000	$8,984,000	$110,000	$10,100,000
3	3,370	3,210	36	2,100	450	$21,650,000	$141,600,000	$2,351,000	$165,700,000	$1,374,000	$8,984,000	$149,000	$10,600,000
4	4,490	4,270	36	2,800	450	$28,860,000	$141,600,000	$2,918,000	$173,400,000	$1,831,000	$8,984,000	$185,000	$11,000,000
5	5,610	5,330	36	3,500	460	$36,080,000	$141,600,000	$3,500,000	$181,200,000	$2,289,000	$8,984,000	$222,000	$11,500,000
6	6,730	6,400	36	4,200	460	$43,290,000	$141,600,000	$4,014,000	$189,000,000	$2,747,000	$8,984,000	$255,000	$12,000,000
7	7,850	7,460	36	4,900	470	$50,510,000	$141,600,000	$4,569,000	$196,700,000	$3,205,000	$8,984,000	$290,000	$12,500,000
8	8,970	8,530	36	5,600	470	$57,720,000	$141,600,000	$5,050,000	$204,400,000	$3,662,000	$8,984,000	$320,000	$13,000,000
9	10,090	9,590	36	6,300	480	$64,930,000	$141,600,000	$5,595,000	$212,200,000	$4,119,000	$8,984,000	$355,000	$13,500,000
10	11,210	10,650	36	7,000	490	$72,150,000	$141,600,000	$6,138,000	$219,900,000	$4,578,000	$8,984,000	$389,000	$14,000,000
11	12,320	11,710	36	7,700	490	$79,360,000	$141,600,000	$6,592,000	$227,600,000	$5,035,000	$8,984,000	$418,000	$14,500,000
12	13,340	12,680	36	8,400	500	$86,580,000	$141,600,000	$7,131,000	$235,400,000	$5,493,000	$8,984,000	$452,000	$15,000,000
13	14,280	13,570	36	9,100	510	$93,790,000	$141,600,000	$7,673,000	$243,100,000	$5,950,000	$8,984,000	$487,000	$15,500,000
14	15,020	14,270	36	9,800	520	$101,010,000	$141,600,000	$8,216,000	$250,900,000	$6,409,000	$8,984,000	$521,000	$16,000,000
15	15,570	14,800	36	10,500	530	$108,220,000	$141,600,000	$8,761,000	$258,600,000	$6,866,000	$8,984,000	$556,000	$16,500,000
16	16,040	15,240	36	11,200	540	$115,440,000	$141,600,000	$9,310,000	$266,400,000	$7,324,000	$8,984,000	$591,000	$16,900,000
17	16,400	15,580	36	11,900	560	$122,650,000	$141,600,000	$9,979,000	$274,300,000	$7,781,000	$8,984,000	$633,000	$17,400,000
18	16,560	15,740	36	12,500	570	$129,870,000	$141,600,000	$10,538,000	$282,100,000	$8,240,000	$8,984,000	$669,000	$17,900,000
19	16,560	15,740	36	13,200	580	$137,080,000	$141,600,000	$11,101,000	$289,800,000	$8,697,000	$8,984,000	$704,000	$18,400,000
20	16,560	15,740	36	13,900	590	$144,290,000	$141,600,000	$11,667,000	$297,600,000	$9,154,000	$8,984,000	$740,000	$18,900,000

APPENDIX C

City of San Diego WPDP

Detailed Cost Breakdown of Project Costs
(Constant 36-inch Conveyance Pipe)

AWPF Capacity (mgd)	Estimated AWPF Product Water Yield (AFY)	AWPF Product Wtr Yield, 95% On-line (AFY)	Adjusted Pipe Dia (in)	Pump Flow Rate (gpm)	Pump TDH (ft)	Annualized O&M Costs				Total Annualized Cost			
						AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)	AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)
1	1,120	1,070	36	700	450	$600,000	$1,022,112	$18,620	$1,700,000	$1,058,000	$10,006,112	$186,070	$11,300,000
2	2,240	2,130	36	1,400	450	$1,300,000	$1,022,112	$31,290	$2,400,000	$2,216,000	$10,006,112	$346,040	$12,600,000
3	3,370	3,210	36	2,100	450	$1,900,000	$1,022,112	$42,420	$3,000,000	$3,274,000	$10,006,112	$489,320	$13,800,000
4	4,490	4,270	36	2,800	450	$2,500,000	$1,022,112	$52,640	$3,600,000	$4,331,000	$10,006,112	$637,840	$15,000,000
5	5,610	5,330	36	3,500	460	$3,200,000	$1,022,112	$63,140	$4,300,000	$5,489,000	$10,006,112	$797,090	$16,300,000
6	6,730	6,400	36	4,200	460	$3,800,000	$1,022,112	$72,415	$4,900,000	$6,547,000	$10,006,112	$941,665	$17,500,000
7	7,850	7,460	36	4,900	470	$4,400,000	$1,022,112	$82,425	$5,600,000	$7,605,000	$10,006,112	$1,098,425	$18,800,000
8	8,970	8,530	36	5,600	470	$5,100,000	$1,022,112	$91,105	$6,300,000	$8,762,000	$10,006,112	$1,239,405	$20,100,000
9	10,090	9,590	36	6,300	480	$5,700,000	$1,022,112	$100,940	$6,900,000	$9,819,000	$10,006,112	$1,405,290	$21,300,000
10	11,210	10,650	36	7,000	490	$6,300,000	$1,022,112	$110,740	$7,500,000	$10,878,000	$10,006,112	$1,579,440	$22,500,000
11	12,320	11,710	36	7,700	490	$6,900,000	$1,022,112	$118,930	$8,100,000	$11,935,000	$10,006,112	$1,728,230	$23,700,000
12	13,340	12,680	36	8,400	500	$7,600,000	$1,022,112	$128,660	$8,800,000	$13,093,000	$10,006,112	$1,902,310	$25,100,000
13	14,280	13,570	36	9,100	510	$8,200,000	$1,022,112	$138,425	$9,400,000	$14,150,000	$10,006,112	$2,086,725	$26,300,000
14	15,020	14,270	36	9,800	520	$8,800,000	$1,022,112	$148,225	$10,000,000	$15,209,000	$10,006,112	$2,270,025	$27,500,000
15	15,570	14,800	36	10,500	530	$9,500,000	$1,022,112	$158,060	$10,700,000	$16,366,000	$10,006,112	$2,463,810	$28,900,000
16	16,040	15,240	36	11,200	540	$10,100,000	$1,022,112	$167,965	$11,300,000	$17,424,000	$10,006,112	$2,657,665	$30,100,000
17	16,400	15,580	36	11,900	560	$10,700,000	$1,022,112	$180,040	$12,000,000	$18,481,000	$10,006,112	$2,907,190	$31,400,000
18	16,560	15,740	36	12,500	570	$11,400,000	$1,022,112	$190,120	$12,700,000	$19,640,000	$10,006,112	$3,092,920	$32,800,000
19	16,560	15,740	36	13,200	580	$12,000,000	$1,022,112	$200,270	$13,300,000	$20,697,000	$10,006,112	$3,305,620	$34,100,000
20	16,560	15,740	36	13,900	590	$12,600,000	$1,022,112	$210,490	$13,900,000	$21,754,000	$10,006,112	$3,528,690	$35,300,000

APPENDIX C

City of San Diego WPDP

Detailed Cost Breakdown of Project Costs
(Constant 36-inch Conveyance Pipe)

AWPF Capacity (mgd)	Estimated AWPF Product Water Yield (AFY)	AWPF Product Wtr Yield, 95% On-line (AFY)	Adjusted Pipe Dia (in)	Pump Flow Rate (gpm)	Pump TDH (ft)	Annual Unit Cost			
						AWPF ($/AF)	Pipeline ($/AF)	Pump Station ($/AF)	Total ($/AF)
1	1,120	1,070	36	700	450	$990	$9,360	$180	$10,530
2	2,240	2,130	36	1,400	450	$1,050	$4,700	$170	$5,920
3	3,370	3,210	36	2,100	450	$1,020	$3,120	$160	$4,300
4	4,490	4,270	36	2,800	450	$1,020	$2,350	$150	$3,520
5	5,610	5,330	36	3,500	460	$1,030	$1,880	$150	$3,060
6	6,730	6,400	36	4,200	460	$1,030	$1,570	$150	$2,750
7	7,850	7,460	36	4,900	470	$1,020	$1,350	$150	$2,520
8	8,970	8,530	36	5,600	470	$1,030	$1,180	$150	$2,360
9	10,090	9,590	36	6,300	480	$1,030	$1,050	$150	$2,230
10	11,210	10,650	36	7,000	490	$1,030	$940	$150	$2,120
11	12,320	11,710	36	7,700	490	$1,020	$860	$150	$2,030
12	13,340	12,680	36	8,400	500	$1,040	$790	$160	$1,990
13	14,280	13,570	36	9,100	510	$1,050	$740	$160	$1,950
14	15,020	14,270	36	9,800	520	$1,070	$710	$160	$1,940
15	15,570	14,800	36	10,500	530	$1,110	$680	$170	$1,960
16	16,040	15,240	36	11,200	540	$1,150	$660	$180	$1,990
17	16,400	15,580	36	11,900	560	$1,190	$650	$190	$2,030
18	16,560	15,740	36	12,500	570	$1,250	$640	$200	$2,090
19	16,560	15,740	36	13,200	580	$1,320	$640	$220	$2,180
20	16,560	15,740	36	13,900	590	$1,390	$640	$230	$2,260