8.3.3.1 Alternative A – Conventional Process using Chloramines for Secondary Disinfection

Description. The liquids process components for this alternative consist of the following:

- Rapid mix structure for mixing coagulant chemicals
- Solids-contact clarifiers
- Dual media filters
- Provisions for installation of UV disinfection in the future
- 2 MG clearwell with chlorine or chlorine dioxide contact chambers

The process schematic for this alternative is shown on Figure 8-1. A summary of the design criteria is shown in Table 8-2 below.

Table 8-2: Alternative A Design Basis

UNIT PROCESS	
Rapid Mix	
Number of Trains	2
Number of Compartments per Train	2
Size, L x W, ft, each Compartment	7 x 7
Sidewater Depth, ft, each	7
Solids Contact Clarifier	
Number of Units	2
Diameter and Sidewater Depth, ft	80 x 12
Detention Time, hrs	2
Filters	
Number of Units	4
Surface Loading Rate, gpm/ sq. ft	5
Size, sq. ft, each	434
Clearwell	
Number	1
Capacity, million gallons	2

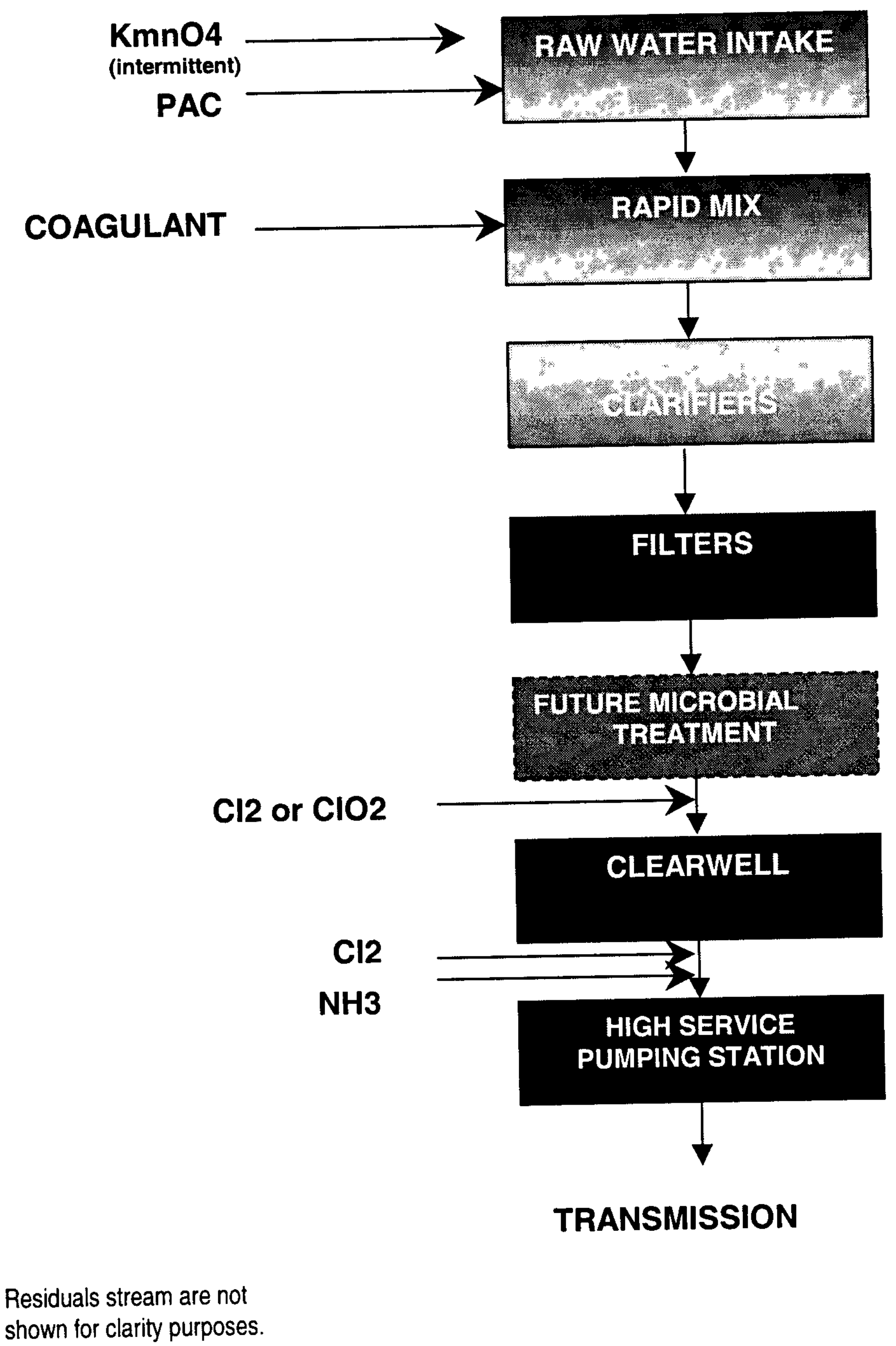


Figure 8-1

Alternative A - Conventional Plant, Chloramine Residual Disinfectant

Discussion. This alternative combines the flocculation and sedimentation process into a single unit enabling higher surface loading rates and shorter detention periods of about 2 hours. Solids contactors rely on a sludge blanket to promote flocculation and subsequent settling of sludge. These units are moderately sensitive to flow fluctuations and water quality variations. However, because the GBRA plant will operate at a consistent flow rate, this is not anticipated to be an issue. Several types of solids contact units exist including the Superpulsator® as manufactured by IDI, Claricone® by Walker Process, and standard circular contactors manufactured by Hi-Tech and several other manufacturers. A standard circular contact clarifier was selected for this evaluation since it is not proprietary like the Walker and IDI units. A solids contactor will achieve between 10 to 20 percent organics reduction, which is insufficient to reduce the level of DBP formation when used in combination with chlorine as a secondary residual disinfectant.

The filters would be standard dual media-type. Although mono-media filters have been promoted to extend filter runtimes and increase the hydraulic loading rates, the current trend is to use dual media filters because they reportedly provide better performance against particle breakthrough. Given the increased emphasis on individual filter performance, dual media filters are recommended for a conventional facility. Each filter would be equipped with filter-to-waste facilities and air scour backwash capabilities.

The contact time for disinfection would occur in entry compartments to a clearwell. Chlorine or chlorine dioxide are preferred options for primary disinfectant for the four alternatives since they are more effective than chloramines and require substantially less contact time to achieve an equivalent level of disinfection. When additional disinfection requirements for inactivation of *Cryptosporidium* are implemented, supplemental disinfection will be needed (i.e. UV).

8.3.3.2 Alternative B – Conventional Process using Chlorine for Secondary Disinfection

Description. The liquids process components for this alternative consist of the following:

- Rapid mix structure for mixing coagulant chemicals
- Solids-contact clarifiers
- Dual media filters
- Granular activated carbon adsorption contactors
- Provisions for installation of UV disinfection in the future
- 2 MG clearwell with chlorine or chlorine dioxide contact chambers

The process schematic for this alternative is shown on Figure 8-2. A summary of the design criteria is shown in Table 8-3 below.

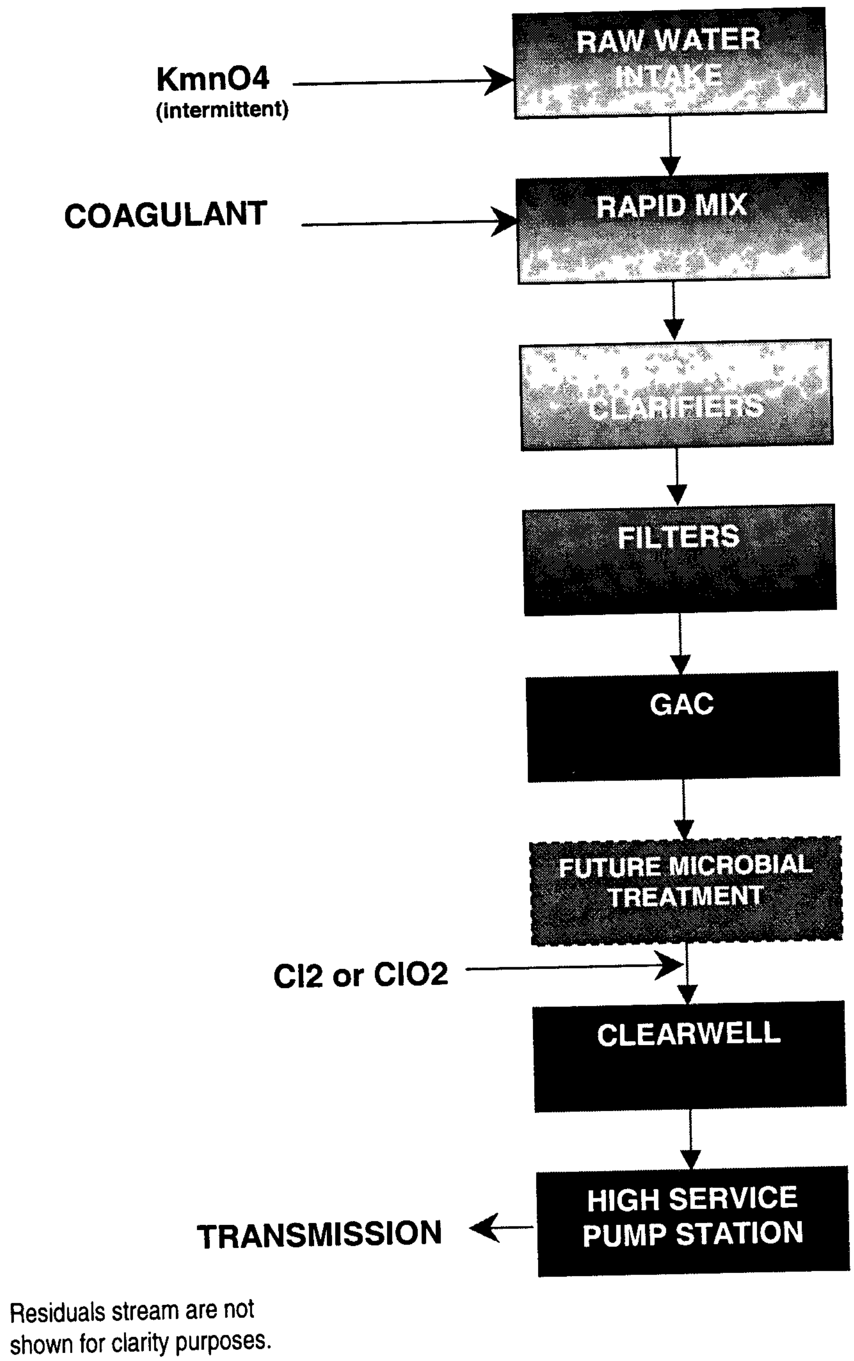


Figure 8-2

Alternative B - Conventional Plant with GAC, Chlorine Residual Disinfectant

Table 8-3 Alternative B Design Basis

UNIT PROCESS	
Rapid Mix	
Number of Trains	2
Number of Compartments per train	2
Size, L x W, ft, each	7 x 7
Sidewater Depth, ft, each	7
Solids Contact Clarifier	
Number of Units	2
Diameter and Sidewater Depth, ft	80 x 12
Detention Time, hrs	2
Filters	
Number of Units	4
Surface Loading Rate, gpm/ sq. ft	5
Size, sq. ft, each	434
GAC Contactors	
Number of Units	4
Surface Loading Rate, gpm/ sq. ft	3 to 5
Empty Bed Contact Time (EBCT), min.	20
Type of Contactor	Gravity
Clearwell	
Number	1
Capacity, million gallons	2

Discussion. This alternative is identical to Alternative A with the exception that post-filtration GAC contactors are included to improve organics reduction so that chlorine can be used as the secondary disinfectant. GAC adsorbs organic precursors resulting in a substantial reduction of DBPs when chlorine is used as the primary/secondary disinfectant. A reduction of greater than 60 to 70 percent is generally achieved with a 20-minute EBCT. While GAC contactors should reduce taste and odor and organic precursor materials leading to less DBP formation, it is relatively costly to install and maintain.

The remaining components of this alternative are identical to Alternative A previously described.

8.3.3.3 Alternative C – MF/UF Membranes using Chloramines for Secondary Disinfection

Description. The liquids process components for this alternative consist of the following:

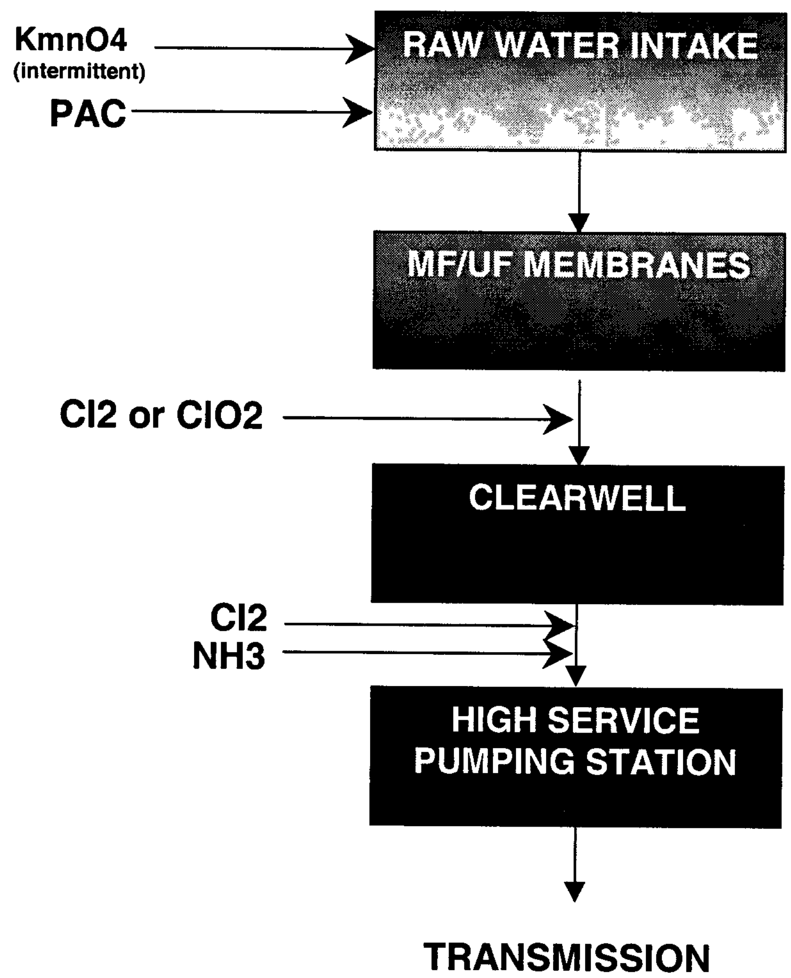
- MF/UF Units
- 2 MG clearwell with chlorine or chlorine dioxide contact chambers

The process schematic for this alternative is shown on Figure 8-3. A summary of the design criteria is shown in Table 8-4 below.

Table 8-4 Alternative C Design Basis

UNIT PROCESS	
MF/UF	
Number of Racks Capacity, mgd, each Design Flux Rate	10 for pressure type 5 for submerged type 1.0 nominal 35 gfd
Clearwell	
Number Capacity, million gallons	1 2

Discussion. Due to the low to moderate turbidity and organic content of Canyon Reservoir water, it is amenable to direct filtration treatment with MF or UF membranes. Membranes produce low turbidity water and serve as a physical barrier again pathogens and potentially some viruses. The loading rates (flux) used in the evaluation are approximate values and should be refined with pilot testing. Pilot testing will likely be required by the TNRCC unless data is submitted for similar waters that rely on membrane treatment. Piloting will further optimize unit sizing, potentially reducing the number of membrane rack and associated costs.



Residuals stream are not shown for clarity purposes.

Figure 8-3
Alternative C - Membrane Plant, Chloramine Residual Disinfectant

8.3.3.4 Alternative D – MF/UF Membranes and NF Organics Removal using Chlorine for Secondary Disinfection

Description. The liquids process components for this alternative consist of the following:

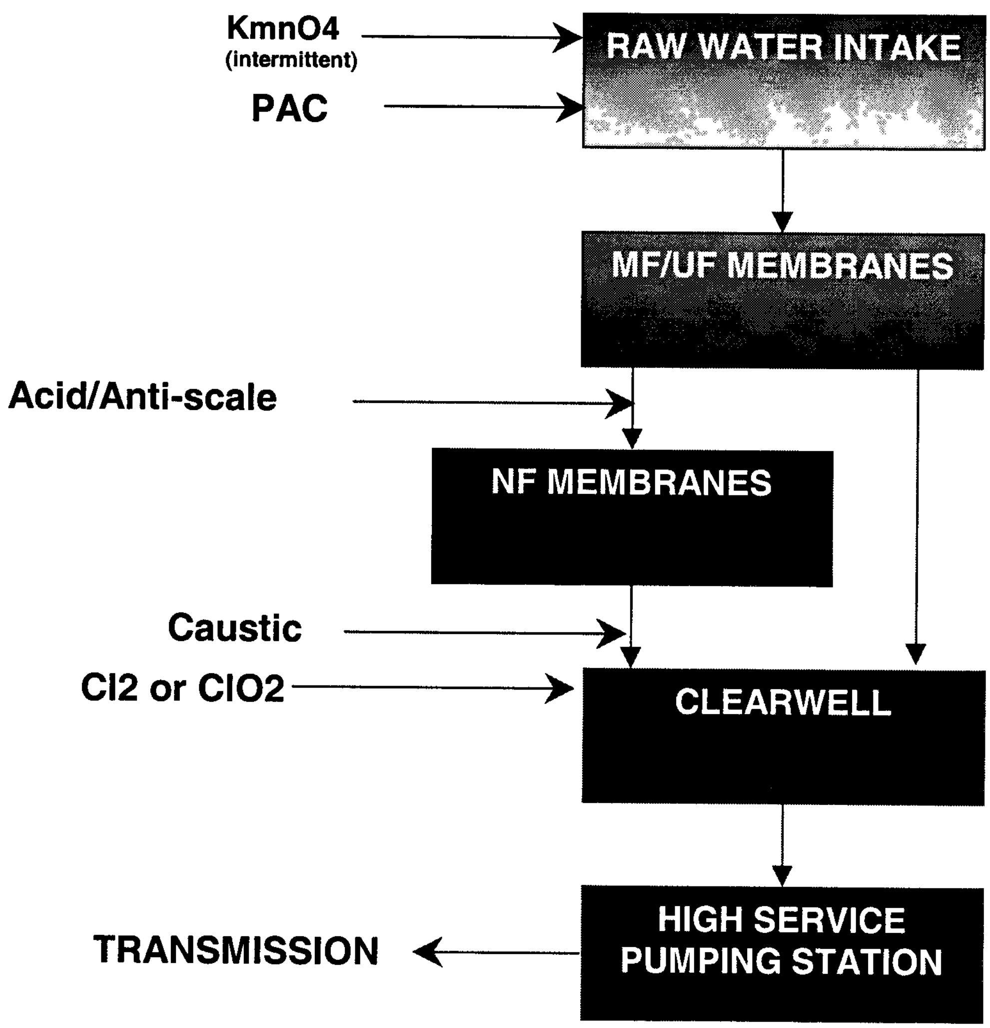
- MF/UF Units
- NF Units
- 2 MG clearwell with chlorine or chlorine dioxide contact chambers

The process schematic for this alternative is shown on Figure 8-4. A summary of the design criteria is shown in Table 8-5 below.

Table 8-5 Alternative D Design Basis

UNIT PROCESS	
MF/UF	
Number of Racks	10 for pressure type 5 for submerged type
Capacity, mgd, each	1.0 nominal
Design Flux Rate	35 gsfd
NF	
Number of racks	3
Capacity, mgd, each	1.66
Design Flux Rate	15 gsfd
Clearwell	
Number	1
Capacity, million gallons	2

Discussion. This alternative is essentially identical to Alternative C except that NF is included to provide organics reduction for about 50 percent of the plant flow. NF will remove about 90 percent of the organic precursors in the treated stream resulting in approximately 45 to 50 percent removal in the combined flow stream. The disadvantage of NF is that additional chemicals are necessary for scale inhibitors and adjusting the pH before and after the units and the resulting waste side-streams.



Residuals stream are not shown for clarity purposes.

Figure 8-4
Alternative D - Membrane Plant with NF, Chlorine Residual Disinfectant

8.3.3.5 Alternative E – MF/UF Filtration and GAC Organics Removal using Chlorine for Secondary Disinfection

Description. The liquids process components for this alternative consist of the following:

- MF/UF Units
- Granular activated carbon contactors
- 2 MG clearwell with chlorine or chlorine dioxide contact chambers

The process schematic for this alternative is shown on Figure 8-5. A summary of the design criteria is shown in Table 8-6 below.

Table 8-6 Alternative E Design Basis

UNIT PROCESS	
MF/UF	
Number of Racks Capacity, mgd, each Design Flux Rate	10 for pressure type 5 for submerged type 1.0 nominal 35 gsfd
GAC Contactors	
Number of Units Surface Loading Rate, gpm/ sq. ft Empty Bed Contact Time (EBCT), min. Type of Contactor	4 3 to 5 20 Gravity
Clearwell	
Number Capacity, million gallons	1 2

Discussion. This alternative is essentially identical to Alternative C except that GAC contactors are included to provide organics reduction in the place of NF so that free chlorine can be used as the secondary disinfectant. The remaining components of this alternative are identical to Alternative C, previously described.

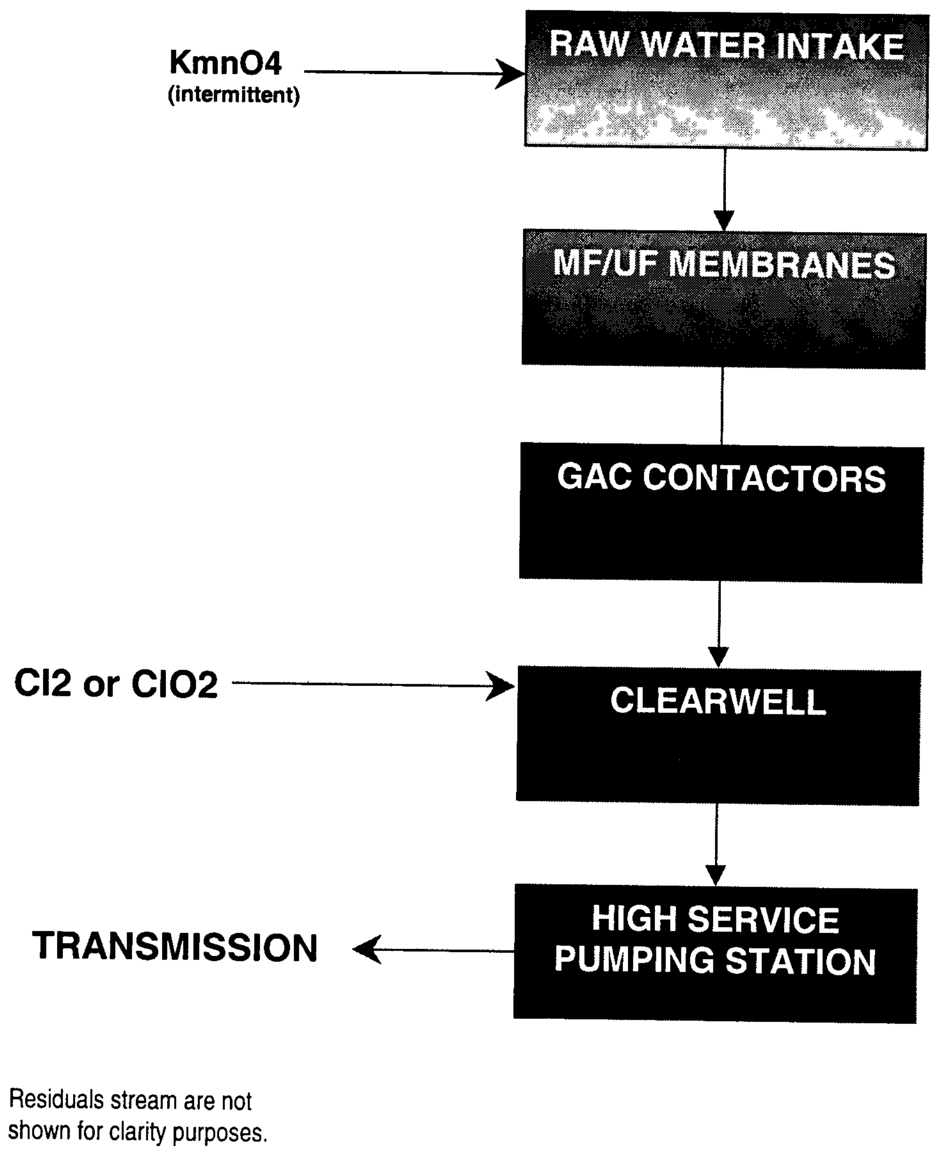


Figure 8-5
Alternative E - Membrane Plant with GAC, Chlorine Residual Disinfectant

Cost-Effectiveness Analysis of Liquid Process Alternatives

Present worth analyses were conducted for each treatment alternative. The analyses included both capital and operation and maintenance (O&M) costs for a 20-year period using March 2000 pricing. Only the liquid treatment component portion of costs are included in the analyses and items such as the raw water intake and pump station and high service pump station are excluded since they are common to each alternative. Residuals treatment costs are defined in Chapter 9. An interest rate of 6 percent was used for the present worth analysis.

Estimated capital, O&M, and present worth costs for the alternatives are shown in Table 8-7. A breakdown of the O&M costs for Alternative B and D is included in Chapter 10.

Table 8-7 Cost-Effectiveness Evaluation of Liquids Treatment Alternatives

Alternatives	Total Capital Costs (Liquids Process)	Planning Period	Annual O&M $/yr.	PW Annual O&M $	Total Present Worth $
A	$9.4 mil	25	$0.8 mil	$10.1 mil	$19.5 mil
B	$16.3 mil	25	$1.4 mil	$17.9 mil	$34.2 mil
C	$8.9 mil	25	$0.9 mil	$11.4 mil	$20.2 mil
D	$15.8 mil	25	$2.1 mil	$27.1 mil	$42.8 mil
E	$15.8 mil	25	$1.6 mil	$19.9 mil	$35.6 mil

1. The capital and O&M costs were derived from Malcolm Pirnie and USEPA cost curves and are for comparison purposes only.
2. Costs include 20% contingency, 5% mobilization/bonds/insurance, and 12% contractor's OH and profit.
3. O&M Costs are combined liquids treatment and residuals treatment, while capital costs are only liquids treatment.

Alternatives A and C, which use chloramines as the secondary disinfectant, are lowest in terms of present worth cost of the alternatives. Of the options where organics reduction is emphasized, Alternatives B and E, which use free chlorine for disinfectant, are relatively similar.

8.4 Disinfection Strategy

The SWTR requires a minimum 3-log removal/inactivation of *Giardia* cysts and a minimum of 4-log removal/inactivation of enteric viruses to protect consumers. From the treatment portion of a conventional plant, a credit of 2.5-log is allowed for removal of *Giardia* and 2-log for removing enteric viruses. The remaining inactivation of 0.5-log *Giardia* and 2-log for enteric viruses must be achieved through disinfection as determined by CT values established in the SWTR. Historically, ozone, chlorine, chloramines, and chlorine dioxide have been used to meet these requirements. Chloramines are the weakest of these disinfectants.

Secondly, the IESTWR when effective will provide a 2-log removal credit for *Cryptosporidium* for plants that achieve the turbidity removal requirements of the rule. Under long-term regulations, additional inactivation requirements for *Cryptosporidium* may be proposed. While the particular details of the additional disinfection requirements are still under negotiation, many utilities that are currently planning for new facilities are including flexibility in plant layouts and infrastructure to accommodate new disinfection processes for Cryptosporidium inactivation. Chlorine, chloramines, and chlorine dioxide are currently not considered effective in inactivating *Cryptosporidium*. Presently ozone is the only oxidant considered effective. However, considerable research is underway in evaluating the effectiveness of combinations of disinfectants (chlorine dioxide/chloramines) and advanced technologies such as UV, which are showing significant promise. Membranes physically remove *Cryptosporidium* by their inherent characteristics and could be recognized as providing a "disinfection" benefit for *Cryptosporidium* in the long-term rules.

Because of the uncertainty of the final rules, it is recommended that a two phased approach (short-term and long-term) be implemented for the GBRA plant as discussed below.

8.4.1 Short-Term Disinfection Approach

8.4.1.1 Primary Disinfection

To reliably meet the disinfection requirements of the SWTR at the treatment plant, either chlorine or chlorine dioxide would be suitable. Chloramines is not recommended since it is not as strong or reliable a primary disinfectant as chlorine or chlorine dioxide. The disadvantage of chlorine and chlorine dioxide is that they produce DBPs. For chlorine, trihalomethanes are problematic unless emphasis is placed on organics reduction within the treatment process. Chlorine dioxide produces chlorite and chlorate, of which only chlorite will be regulated in the Stage 1 D/DBP rule (MCL of 1.0 mg/L). However, based on our experience, it is possible the level of chlorine dioxide required to meet SWTR disinfection requirements would likely not exceed the chlorite MCL. Before chlorine dioxide is considered further, testing should be performed to determine the maximum dosage that could be applied without exceeding the chlorite MCL.

While either disinfectant will meet current disinfection requirements, it is recommended that chlorine dioxide be analyzed for implementation provided the GBRA is comfortable with the level of additional monitoring and reporting that will be necessary to gain state approval.

8.4.1.2 Residual Disinfection

Because of long residence times and the level of available organic precursors remaining in conventionally treated Texas surface waters, chloramines is the secondary disinfectant of choice to minimize DBP formation in most transmission pipelines. Based on our discussions with water utilities whose customers combine chloraminated treated surface water with chlorinated supplies, there are more frequent taste and odor events, periodic depletion of chlorine residual in blending zones, and instances of excessive DBP formation when breakpoint chlorination occurs. As a result, some utilities have been moving toward a compatible disinfectant approach of either all chloramines or all chlorine. This means that some customers that use free chlorine on groundwater, for example, find themselves changing their disinfectant to chloramines to avoid the higher treatment costs to remove organics and the other negative factors previously discussed. For those customers that will use the GBRA plant as their only source, the impact of the disinfectant choice would be minimal while customers that currently use chlorine would be faced with a choice to either change to chloramines or deal with the potential side impacts.

However, because the GBRA and their customers have established water quality objectives whose goal is to minimize tastes and odors and avoid change to their current disinfection practices, free chlorine is the preferred choice. Consequently, the treatment plant process that is selected should incorporate improved organics removal capability so that free chlorine can be used as the secondary disinfectant while complying with the D/DBP requirements for TTHMs and HAAs.

8.4.2 Long-Term Disinfection Approach

While the long-term disinfection requirements of future rules are not clearly defined at this time, a membrane process will likely provide the most benefit since additional processes to inactivate *Cryptosporidium* will likely not be required. If a conventional process is used, space should be allotted to install advanced processes such as UV to address *Cryptosporidium.*

8.5 Evaluation of Liquids Treatment Technology Alternatives

The five alternatives were evaluated in terms of cost-effectiveness and qualitative (non-monetary) criteria. The cost-effectiveness analysis was based on the estimated present worth of capital and O&M costs. The qualitative analysis compared the alternatives on criteria such as water treatment effectiveness, treatment reliability, O&M requirements, flexibility, etc.

Each alternative was ranked within each factor on a scale of 1 to 5. The higher the score, the more favorable the rating. Recognizing that each factor has a different importance to the objectives of the project, a weighted factor was applied to each category. Table 8-8 below summarizes the rating criteria and importance factor. The results of the analyses are indicated in Table 8-9.

Table 8-8: Qualitative Criteria and Importance Factor

Criteria	Weight
Treatment Effectiveness	40%
Reliability	8%
O&M Requirements	8%
Cost	40%
Plant Flexibility	2%
Other	2%

Treatment effectiveness and cost were rated on an equal basis since the water quality objectives articulated by GBRA and their customers highly influences the process selection and costs.

Table 8-9: Treatment Technology Evaluation Matrix

	CRITERIA	CONVENTIONAL		MEMBRANE		
		Alt. A Chloramines	*Alt. B Chlorine*	*Alt. C Chloramines*	*Alt. D Chlorine*	*Alt. E Chlorine*
1	***Treatment Effectiveness***					
	Particle Barrier/Removal Efficiency	2	3	5	5	5
	Disinfection	3	3	4	5	4
	Organics Removal	3	5	3	4	5
	Aesthetics (T&O)	3	5	3	4	5
	Ability to meet Future Regulations	4	4	5	5	5
	SUBTOTAL	**15**	**20**	**20**	**23**	**24**
2	***Reliability***					
	Least sensitive to raw water quality and temperature changes.	3	4	3	3	3
	Long-term performance history	3	4	4	3	4
	Low Operations risks (common treatment plant failures)	4	4	5	2	5
	Equipment Service capability/ warranty	3	3	3	3	3
	SUBTOTAL	**13**	**15**	**15**	**11**	**15**
3	***Least O&M Requirements***					
	Most familiar technology to operators	5	4	3	2	3
	Least experience and least number of operators required.	4	4	5	2	4
	Least complex operation (required capacity of operating staff and laboratory monitoring)	4	3	5	2	4
	SUBTOTAL	**13**	**11**	**13**	**6**	**11**

CRITERIA		CONVENTIONAL		MEMBRANE		
		Alt. A Chloramines	Alt. B Chlorine	Alt. C Chloramines	Alt. D Chlorine	Alt. E Chlorine
4	***Lowest Cost***					
	Required plant size	4	4	4	3	4
	Site land requirements.	4	3	5	3	4
	Housing requirements.	4	3	4	2	4
	Residuals system requirements.	4	5	5	2	4
	Lowest construction costs.	4	3	4	2	3
	Electrical power cost.	5	5	3	2	3
	Chemical costs.	3	3	5	2	4
	Operation and maintenance costs.	5	3	5	2	3
	Number of equipment manufacturers/ competition.	4	4	4	4	4
	Constructability.	3	4	5	3	4
	SUBTOTAL	**40**	37	**44**	**25**	**37**
5	***Plant Flexibility***					
	Flexibility of plant arrangement for future changes.	3	5	4	3	5
	SUBTOTAL	**3**	**5**	**4**	**3**	**5**
6	***Other***					
	Shortest time to construct plant.	4	4	5	3	4
	Least amount of water lost for backwash, etc.	5	2	4	2	2
	Pilot testing requirements.	5	4	3	2	3
	Instrumentation and Control Requirements.	5	4	3	2	3
	SUBTOTAL	**19**	**13**	**15**	**9**	**12**

The results of the evaluation are indicated in Table 8-10 below.

Table 8-10: Evaluation Summary of Treatment Technology Selection

	CRITERIA	Weight (%)	CONVENTIONAL				MEMBRANE					
			Alternative A Chloramines		Alternative B GAC/ chlorine		Alternative C Chloramines		Alternative D NF/ chlorine		Alternative E GAC/ chlorine	
			Raw Subtotal	Weighted Subtotal	Raw Subtotal	Weighted Subtotal	Raw Subtotal	Weighted Subtotal	Raw Subtotal	Weighted Subtotal	Raw Subtotal	Weighted Subtotal
1	Treatment Effectiveness	40%	15	6.0	20	8.0	20	8.0	23	9.2	24	9.6
2	Reliability	8%	13	1.0	15	1.2	15	1.2	11	0.9	15	1.2
3	O&M Requirements	8%	13	1.0	11	0.9	13	1.0	6	0.5	11	0.9
4	Lowest Cost	40%	40	16.0	37	14.8	44	17.6	25	10.0	37	14.8
5	Plant Flexibility	2%	3	0.1	5	0.1	4	0.1	3	0.1	5	0.1
6	Other	2%	19	0.4	13	0.3	15	0.3	9	0.2	12	0.2
	TOTAL	100%		24.5		25.2		28.2		20.8		26.8
	Overall Rank		4		3		1		5		2	

Legend

- Alternative A – Conventional plant; chlorine or chlorine dioxide for primary disinfection with provisions for addition of UV in future; chloramines for secondary disinfectant through the transmission line. (Screening alternatives 18 and 20)
- Alternative B – Conventional plant; GAC for organics reduction; chlorine or chlorine dioxide for primary disinfection with provisions for addition of UV in future; chlorine for secondary disinfectant in the transmission line. (Screening alternative 10)
- Alternative C – MF/UF membranes; chlorine or chlorine dioxide for primary disinfection; chloramines for secondary disinfectant through the transmission line. (Screening alternatives 21, 22 and 23)
- Alternative D – MF/UF membranes; NF for organics reduction; chlorine or chlorine dioxide for primary disinfection; chlorine for secondary disinfectant through the transmission line. (Screening alternatives 13 and 17)
- Alternative E – MF/UF membranes; GAC for organics reduction; chlorine or chlorine dioxide for primary disinfection; chlorine for secondary disinfectant through the transmission line. (Screening alternatives 13)

8.6 Recommended Treatment Technology

Based on the evaluation, Alternative C (membrane plant and chloramines disinfection) ranks the highest, while Alternative E (membrane plant and GAC with free chlorine) ranks second. Although the ranking factors for water treatment effectiveness and costs were factored on a level basis, the advantages of the treatment process are not enough to overcome the cost differences.

As a consequence, the decision whether to select Alternative C or E would be somewhat driven by cost unless the foremost objective is to meet the water quality objectives. In this case, only those options that meet those objectives should be compared (Alternatives B, D and E). On this basis, Alternative E ranks highest and is recommended. This alternative has the lowest capital cost of the three and a comparable O&M cost to Alternative B; provides superior particle reduction and protection from microbials; and enables the GBRA to meet the requirements of anticipated long-term regulations. It is further recommended that pilot testing be conducted on membranes to select the type of membrane and develop the design flux (loading) rate and to optimize the selection and sizing of the GAC facilities. Membrane piloting also allows for more accurate cost opinions, and is necessary for achieving approval from the TNRCC. "Augmented membranes" or membrane pretreatment evaluations can also be included in the pilot study to analyze the potential for additional upfront organics removal in order to optimize GAC system usage and operation. Independent of the selected treatment process, bench-scale GAC pilot tests (such as accelerated column tests) are recommended in order to more accurately define the carbon usage rate.

8.6.1 Discussion of Membrane Treatment and Conventional Treatment

Due to the emphasis of regulations on microbial and particle reduction, water utilities within this country are considering and implementing membrane plants. While Europe has used membranes for water treatment for some period of time, US utilities recently entered the arena, therefore this country's operating experience and regulatory acceptance of membranes is rather limited. However, it is becoming recognized in certain instances as an appropriate technology and costs are becoming more competitive with conventional plants as its use expands.

Within Texas, membrane plants have been installed and accepted by the TNRCC for potable water treatment (San Patricio Municipal Water District and Bexar Metropolitan). In the case of the new GBRA plant, a membrane facility would present the following advantages and disadvantages:

Advantages	Disadvantages
• Coagulant chemicals are not needed to remove the turbidity from the water – no pretreatment needs. • Provides disinfection capability and is an absolute barrier against microbial breakthrough. • Will likely be given credit for removal of *Cryptosporidium* whereas conventional plants will need additional components to achieve inactivation credit (ozone, UV, etc). • Produces a consistent finished water quality – less subject to raw water variations. • Less operator attentiveness is needed since the racks are automated. • Less residuals handling since coagulant chemicals are not used.	• Unfamiliar technology to GBRA. • Pilot testing will be required to obtain TNRCC approval. • Not as effective as conventional treatment for removing organics. • Membranes need routine placement to maintain full production capacity. • Higher electrical costs due to pressure requirements.

Because a membrane facility provides additional benefits not afforded by conventional treatment in a comparable cost, it is the recommended technology for treating the Canyon lake water. Coupled with GAC, this total plant can meet the water quality objectives stated for this project.

8.7 Taste and Odor Control

Historically, from data collected at the Canyon Lake WSC Triple Peak plant, taste and odor has not been an issue with the source supply. Two common approaches used in surface supplies are potassium permanganate and either powdered or granular activated carbon addition.

Potassium permanganate is relatively effective for oxidizing odor-related compounds and in reducing accumulations inside pipelines. Activated carbon is considered the most effective treatment when adequate contact time is provided. A secondary benefit of activated carbon is that it will adsorb the organic precursor materials that form chlorinated DBPs. While KmnO4 is effective for some types of T&O compounds, it is not reported to be very effective for removing earthy-musty tastes and odors resulting from algal activity in natural water bodies. PAC or GAC is more effective in removing these compounds.

For the recommended Alternative E, the GAC contactors would adsorb the odor-related compounds. Therefore, PAC would not be necessary for this alternative. Facilities to feed potassium permanganate should be installed near the intake for bio-film control inside the raw water pipeline.

8.8 Corrosion Control

For Alternative E, the finished water pH, alkalinity, and hardness is estimated to be between 8.0 to 8.2, 150 to 200 mg/L, and 106 to 250 mg/L, respectively. Therefore, no additional corrosion control measures are anticipated. Further, in 1998, Malcolm Pirnie conducted chemical compatibility tests of treated Canyon Lakes water with Edwards aquifer water. From the study, it was determined that these tested blends should be stable and not result in chemistry changes that would promote corrosion or precipitation in the customers systems. Space should however be allocated within the plant to install a sequestering agent if water quality varies in the future where corrosion control measures would be needed.

Regional Water Supply Project for Portions of Comal, Kendall, and Bexar Counties

Residuals Management Evaluation

Technical Memorandum

Table of Contents

9. Residual Management Evaluations

9.1. Introduction

This section discusses the selection of a residuals treatment process. Because this evaluation occurs concurrently with the treatment technology evaluations, multiple residual management approaches have been developed. The two treatment alternatives under consideration are conventional treatment and microfiltration/ultrafiltration (MF/UF) membrane filtration. Both plant alternatives have granular activated carbon (GAC) contactors to remove total organic carbon (TOC) and potential taste and odor compounds.

9.2. General Residuals Information

The purpose of a residuals process is to reuse, reduce, and remove anything left from the water treatment process. Typical residuals processes include flow equalization basins, a thickening process, a dewatering process and final disposal of residuals. The flow equalization basin settles out some of the solids where possible, allows for recycling water to the water treatment plant inlet, and provides a steady flow to the next steps in the residuals treatment process. The thickening process concentrates the residuals before dewatering and recycles more water to the water treatment plant inlet. Finally, the dewatering process prepares the residuals for final disposal. Design of a water treatment plant residuals system is based on government regulations and requirements, the raw water quality and characteristics, and site conditions, as well as the type of treatment systems used.

9.2.1. Regulations

The following codes and regulations are applicable to the disposal of residuals:

- Texas Natural Resource Conservation Commission (TNRCC) Chapter 290, Subchapter D.
- Texas Pollutant Discharge Elimination System (TPDES) Discharge Permit Standards

TNRCC requires that the return of the decant (recycle) water to the raw water intake be controlled in order to minimize interference with the treatment process. Future recycling requirements could limit the maximum recycle rate to 10% of plant flow and/or limit recycle water turbidity to a maximum of 2 NTU. In order to obtain the turbidity limit and also reduce the return of microbials to the front of the plant, a conventional filtration system may require additional treatment prior to recycling, such as a small membrane system or pressure filter. Because membranes provide a physical barrier to microbials, it is unlikely that decant water from a membrane system would need additional treatment before recycling.

9.2.2. Raw Water Characteristics

The two raw water characteristics that affect residuals volume and handling are turbidity and total suspended solids (TSS). Table 9-1 contains the raw water quality assumptions used in estimating sludge production. Preliminary residuals system sizing is based on a conservative value of 1.5 for the TSS/Turbidity ratio, along with the 90th percentile turbidity of approximately 5 NTU.

Table 9-1: Typical Raw Water Quality Assumptions

Water Characteristics	Average Value (50th Percentile)	Max. Value (90th Percentile)
Turbidity	2 NTU	4.8 NTU
TSS	4 mg/L	7 mg/L
TSS/Turbidity Ratio	2.0	1.5

9.2.3. Site Conditions

Site conditions will also affect the residuals process selection. The general area (near Canyon Lake) has a net pan evaporation rate of 70 in/yr, which indicates that air drying systems may be preferred over more operation intensive mechanical systems. The specific water treatment plant site is still being evaluated, which may also modify the residuals process shown in this technical memorandum. Specifically, the preferred method of residuals transfer is by gravity flow, but more pumping may be required depending on the layout and elevations of the chosen plant site.

9.3. Conventional Treatment Plant Option

Conventional filtration can produce multiple types of residuals for disposal based on the water quality and the exact type of treatment systems used. It is assumed that treatment will consist of a solids contact clarifier and filtration unit. Residuals produced include:

- Coagulant sludge from the solids contact clarifier
- Filter wash water solids

Ferric sulfate could be used as the primary coagulant in the system. However, enhanced coagulation methods, such as polymer addition, may produce additional residuals. A small continuous stream of sludge would be produced from the gravity thickeners and routed to the gravity thickners.

9.4. Membrane Filtration Plant Option

The membrane treatment plant option will produce residuals from pretreatment, membrane filter backwashing, and membrane cleaning.

9.4.1. Pretreatment

Most membrane manufacturers recommend a 200 micron strainer upstream of the membranes to avoid fouling. Typical backwash (cleaning) for strainers is activated when a pressure loss of 3 to 5 psi occurs. Flow to the membrane system is uninterrupted during the strainer's backwash. Backwash operation will occur approximately three times a day for each of the three strainers, at 200 gallons per backwash cycle. Because of its high grit content, strainer wash water would be sent directly to sludge drying beds.

9.4.2. MF/UF Membranes

MF and UF membranes produce two types of waste:

- Wash water (from membrane backwash operation)
- Membrane cleaning waste or CIP (clean in place) residuals, which may occur at one to three month intervals (conservative assumption)

Assuming that MF/UF membranes operate with a dead-end flow system, all reject material will be removed with the wash water waste and no "brine" will be produced.

Membrane backwashing occurs at an approximate rate of 2000 gpm for a one minute time duration, followed by a five to six minute time lag before the next backwash cycle begins. A flow equalization basin will be provided to produce a more steady flow rate to the solids thickening process. Approximately 500,000 gallons per day of wash water are produced by the membrane backwash system.

9.4.3. MF/UF CIP Residuals Sizing

Approximately 10,000 gallons of cleaning solution are produced for cleaning each unit. In addition, the MF/UF CIP solution may be neutralized with a caustic solution, prior to disposal. For preliminary design sizing, it was assumed that one membrane unit would be cleaned once a month, with a worse case condition of two units being cleaned. This is a conservative assumption representing worst-case scenario conditions. Cleaning frequency will be established during pilot testing. Two typical alternatives for disposal of CIP waste include direct disposal to a sanitary sewer or disposal to a holding tank, with removal by a septic tank truck(s). Because there are no sanitary sewers close to the treatment plant, a holding tank, sized to hold two cleanings, should be provided.

9.5. GAC

GAC contactors will be used with either a conventional or MF/UF membrane treatment plant, and the residuals produced from the GAC apply to both alternatives. The GAC units will be downstream of either treatment system and will produce very little residual volume. GAC systems produce two types of residuals: carbon fines from the initial GAC start-up operation, which are typically washed out in the first day or two of operation; and influent solids which are removed during backwashing of the GAC bed. Also removed during the backwash cycle are GAC fines produced by particle abrasion during backwashing. The backwash interval is estimated between 6 and 12 months. Depending on whether the GAC system is utilized at full capacity or partial capacity (during flow splitting), regeneration may be required in less than 6 months. In this case, the backwash interval would rely on the anticipated regeneration interval. Backwash of the GAC system will require high flow rates to achieve a 35% bed expansion. The backwash time duration is similar to conventional dual media gravity filters. The approximate volume of the GAC wash water is 870,000 gallons.

9.6. Estimated Residuals Production for Treatment Alternatives

Table 9-2 contains the estimated residual production for each of the 10 MGD treatment processes. Residual quantities are shown in both dry pounds of solids produced per day and gallons of liquid containing the residual solids produced per day. The dry pounds of solids remains constant throughout the residuals treatment process, while the liquid gallons per day will be reduced as the residuals are further processed and the residual concentration increased.

Table 9-2: Treatment Processes and Estimated Residuals Produced

Parameter	Design Value	Residuals (dry lb/d)	Residuals (GPD)
CONVENTIONAL TREATMENT			
Raw Water Characteristics Turbidity[1]	5 NTU	630	1,580,000
Pretreatment PAC	15 mg/L	1250	Incl. Above
Conventional Treatment Ferric Sulfate	40 mg/L	970	Incl. Above
MEMBRANE TREATMENT			
Raw Water Characteristics Turbidity[1]	5 NTU	630	500,000
Membrane Treatment CIP Waste Stream[2]	10,000 gal/cleaning	-	10,000 gal/ month
GAC			
Additional Fines	870,000± gal/BW	-	870,000±/six months

[1]GPD is dependent on residuals concentration leaving the treatment system and a plant flow of 10 MGD.
[2]Assumes maximum membrane cleaning frequency of once per month.

9.7. Flow Equalization

Both the conventional and MF/UF treatment options will require flow equalization prior to residuals discharging to the thickening process. For a conventional treatment plant, a flow equalization basin will be provided, consisting of two cells of 1,580,000 gallons each. This will hold two days volume of conventional residuals production and provide volume for GAC wash water.

For MF/UF membrane treatment, a flow equalization tank of 30,000 gallons will be provided for the membrane backwash. A separate wash water equalization lagoon will be supplied for the GAC backwash. This equalization lagoon will operate as a retention basin and slowly recycle wash water back to the front of the plant. The inlet pipe will include an isolation valve and an energy dissipater, and the outlet pipe will allow decanting at multiple levels and complete drainage of the lagoon. The entire lagoon surface will be covered by several inches of a non-permeable lining to prevent groundwater contamination. Area requirements for the lagoon also include access.

9.8. Thickening Processes

For either the conventional or MF/UF treatment, the residuals should be thickened prior to dewatering. The percent solids achieved is dependent on the particular sludge to be treated and coagulant addition. Options for thickening include dissolved air flotation (DAF) and a gravity thickener. For these processes, a wash water recycle pump will be provided to transfer water to the plant inlet.

9.8.1. Gravity Thickener

A gravity thickener is normally comprised of a circular tank with a center feed well. The residuals flow stream enters the tank up through this center feed well and then settles to the bottom of the tank. The concentrated residuals are removed by scrapers and sent to the dewatering process, while the clarified effluent is pumped to the beginning of the water treatment process.

A gravity thickener is the recommended for the conventional treatment plant option. Residuals from the conventional plant solids contact clarifier and the filter wash water will be discharged to the equalization basins. Residuals from the equalization basins would flow by gravity to the gravity thickener for thickening to approximately 3 to 4 percent solids. From the gravity thickener, the residuals would be discharged to the dewatering facility. Alternately, the residuals flow stream from the solids contact clarifier could flow directly to the gravity thickener, or flow from the equalization basins could bypass the gravity thickener and discharge to the dewatering facility. The thickening system includes two gravity thickeners (one standby) and a coagulant feed system.

9.8.2. DAF

In the DAF process, recycle water and compressed air are combined and fed into a tank containing the residuals flow stream. As the recycle water is depressurized, tiny bubbles form, lifting residuals to the top of the tank and concentrating them for removal. The concentrated solids are removed by a skimmer and sent to the dewatering facility, while clarified effluent is pumped to the plant inlet.

DAF thickening is considered effective for MF/UF treatment, because it can treat lower solids concentrations better than gravity thickeners. Wash water from the membranes will be discharged to the DAF for thickening to approximately 4 percent solids. From the DAF, concentrated residuals would be gravity fed to the dewatering facility. The thickening facility would include two DAF systems (one standby), an external air supply, and a coagulant feed system.

Approximately one pound of a non-polymer coagulant, such as aluminum sulfate or ferric chloride, will need to be added per pound of TSS to achieve the target concentration. Approximately 491,000 gallons of the membrane wash water flow would be recycled from the DAF unit pump station to the WTP inlet. Approximately 9,000 gallons of residuals concentrate would be discharged from the DAF system to the dewatering processes.

9.9. Dewatering Processes

Options for dewatering include sludge lagoon beds, sand drying beds, centrifuge dewatering facilities, vacuum assisted drying beds, and belt filter presses. Although mechanical dewatering facilities could be used to effectively process the thickened residuals, the relatively high evaporation rate at Canyon Lake suggests that evaporative drying/dewatering processes, such as sludge lagoons or sand drying beds, would be a simpler to operate and a more economical option. Sludge lagoons or sand drying beds could be used for either conventional or membrane filtration. A summary of the advantages and disadvantages of air drying systems is provided in Table 9-3.

Table 9-3: Advantages and Disadvantages of Air Drying Systems

Advantages	Disadvantages
• Low energy requirements • Does not require continuous operator attention. • Low maintenance. • Easy to construct. • Lower capital and operational costs than mechanical processes	• Possible odor and vector problems. • Large land requirements

Sand drying beds are the recommended dewatering process. Although sludge lagoons could be used as part of the dewatering process, the residuals leaving the lagoons would require additional treatment or handling before disposal. Sand drying beds can provide residuals ready for off-site disposal and allow more water to be recycled back to the water treatment plant.

Residuals from the DAF or gravity thickener will be gravity fed to the drying beds facility. The drying bed facility would include four separate drying beds and a decant pump system for removing excess water. The finished residuals will contain between 25 and 50% solids. The shallow sand beds will include an underdrain system, and a layer of gravel at 2 feet deep, and a layer of sand one foot deep. With the MF/UF membrane option, the wash water equalization lagoon for the GAC backwash could temporarily store residuals during the winter months if evaporation and/or use of the drying beds are restricted.

9.10. Sizing and Design Criteria

Sizing and design criteria for the various residuals treatment processes are shown in Table 9-4. Schematics for the residuals produced by the different water treatment processes and residuals management are also presented.

Table 9-4: Design Criteria

Parameter	Design Value
CONVENTIONAL TREATMENT	
Influent Characteristics	
Lbs. of residuals per day from turbidity	630
Lbs. of residuals per day from PAC addition	970
Lbs. of residuals per day from ferric sulfate addition	1250
Total lb of residuals per day	2850
Flow Equalization Basin	
Number of cells	2
Volume per cell, gal	1,580,000
Sidewater depth (with freeboard), ft	14
Dimension of each cell, ft	Length =245 Width =70
Thickening –Gravity Thickener	
Number of units	2 (one standby)
Hydraulic loading rate (gpm/ft^2)	0.12
Diameter, ft	34
Sidewater depth (with freeboard), ft	10
Dewatering – Sand Drying Beds	
Number of Sand Drying Beds	4
Dimension of each bed, ft	Length =150 Width =50

Parameter	Design Value
Area required by beds and access, ac	1±
Access road width, ft	12
MEMBRANE TREATMENT	
Influent Characteristics	
Lbs. of residuals per day from turbidity	630
Lbs of residuals per day from DAF added coagulant	630
Total lb of residuals per day	1260
Flow Equalization Tank	
Volume, gal	30,000±
Height, ft	15
Tank Diameter, ft	20
Thickening – DAF	
Number of Units	2 (one standby)
% Recycle	25
Lb coagulant added/lb TSS	1
Hydraulic loading rate (gpm/ft^2)	2
Flotation Diameter, ft	17
Diameter, ft	18
Sidewater Depth, ft	6.5
Lbs. Air required/ lbs. Solids	0.02
GAC Wash water Equalization Lagoon	
Flow to lagoon, gal	870,000± gal
Depth of Lagoon, ft	10
Side slope	3:1
Dimension of lagoon, ft	Length =215 Width =75
Dewatering – Sand Drying Beds	
Number of Sand Drying Beds	4
Dimension of each bed, ft	Length =100 Width =25
Area required by beds and access, ac	0.5
Road width, ft	12
MF/UF Membrane CIP Waste	
Number of storage tanks	1
Depth, ft	16
Diameter, ft	40

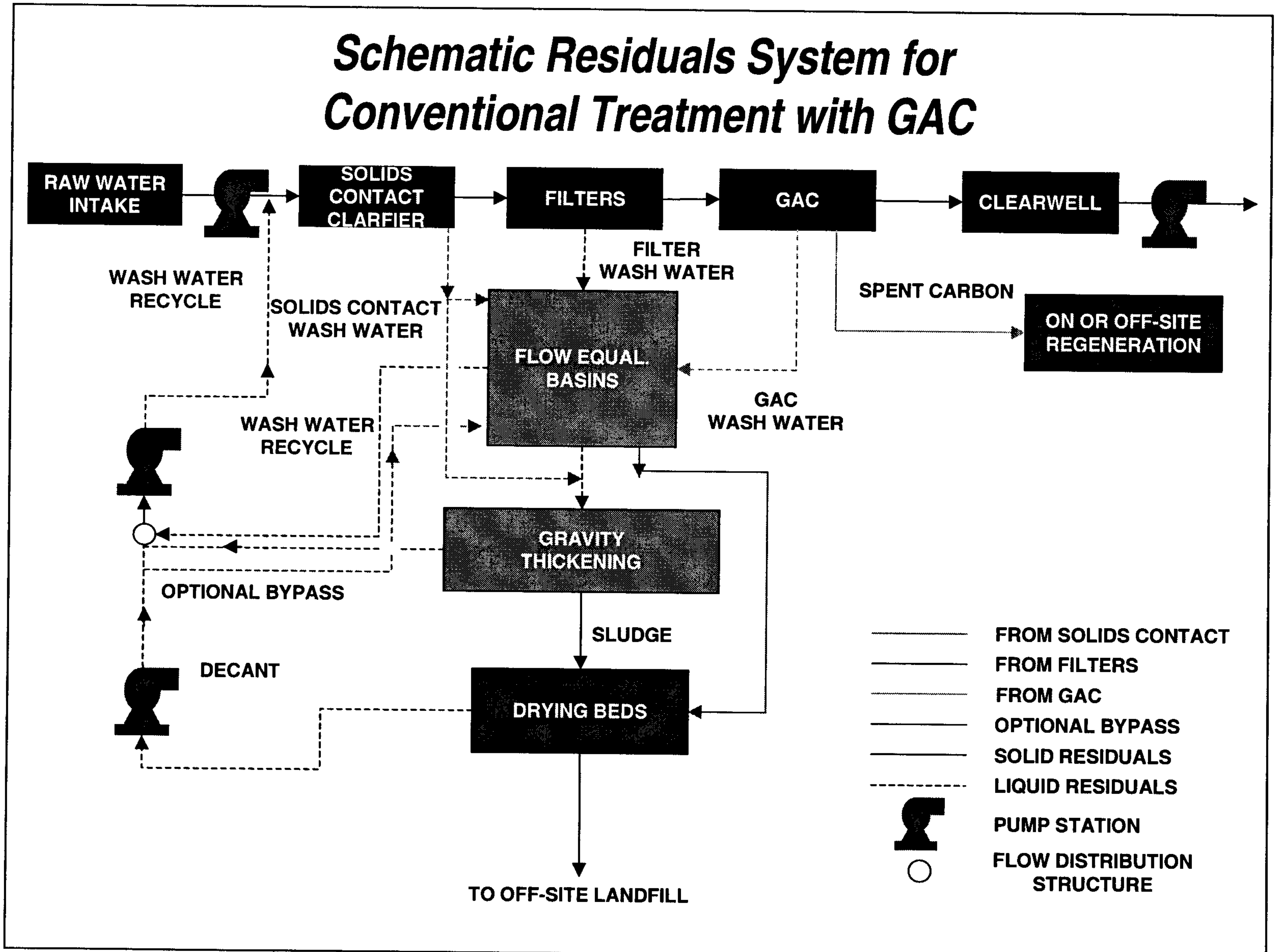


Figure 9-1: Schematic Residuals System for Conventional Treatment with GAC

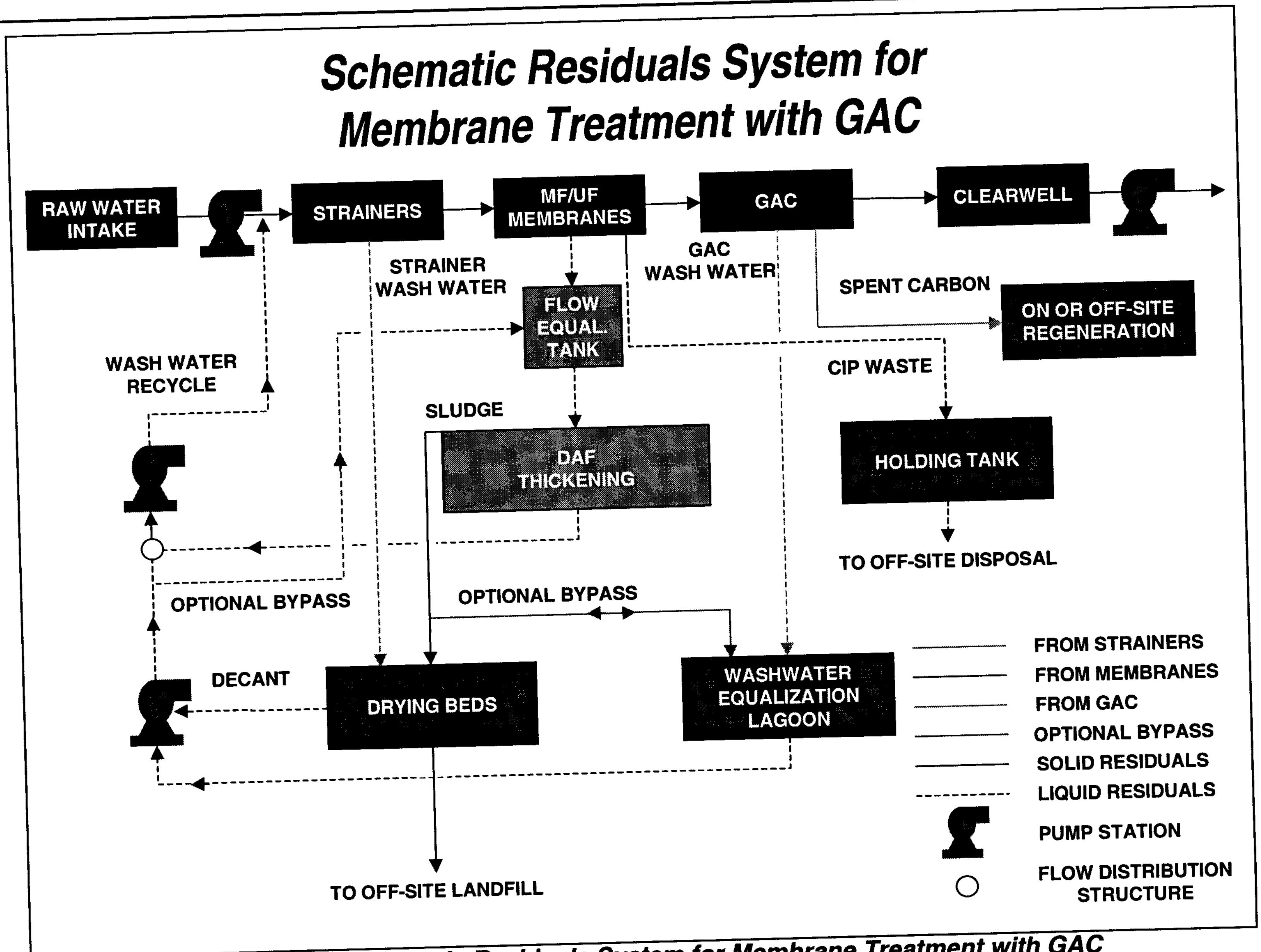


Figure 9-2: Schematic Residuals System for Membrane Treatment with GAC

9.11. Cost Evaluation

Table 9-5 presents the capital costs associated with the residuals treatment alternatives.

Table 9-5: Capital Cost Opinion

Treatment System	Conventional w/GAC	Membrane w/GAC
Thickening Unit (DAF or Gravity Thickener)	$655,000	$1,070,000
Drying Beds	$268,000	$165,000
Equalization Unit (Tank or Basin)	$318,000	$100,000
Washwater Equalization Lagoon (for Membrane GAC)	N/A	$261,000
Pump Stations	$200,000	$200,000
Subtotal	**$1,441,000**	**$1,796,000**
Contingency (20%)	$288,000	$359,000
Subtotal	**$1,729,000**	**$2,156,000**
Mobilization/Bonds/Insurance (5%)	$86,000	$108,000
Contractor OH&P (12%)	$208,000	$259,000
Total	**$2,023,000**	**$ 2,522,000**

Regional Water Supply Project for Portions of Comal, Kendall, and Bexar Counties

Operations Planning and O & M Definition

Technical Memorandum

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10. Operations Planning and O & M Definition

10.1 Background

The purpose of this section is to present the operating and maintenance requirements for the new water treatment facilities. The section includes a description of the proposed operational approach, number and type of staff to operate the facility, approximate staffing and maintenance costs, and operating costs in terms of electrical and chemicals used.

10.2 Operational Approach

10.2.1 Philosophy

GBRA currently operates several different types of facilities in several locations. In order to fully integrate a new water treatment and delivery system into the existing organization several factors should be considered.

- The existing GBRA organization
- The facilities that will comprise the overall project
- The operational and functional areas that will be required to properly operate and maintain the new facilities

10.2.2 Existing Organization

Currently, the upper basin utility operations of GBRA facilities is organized into nine areas, each reporting back to the Manager of Utility Operations. These nine areas are:

- San Marcos Water Treatment Plant
- Luling Water Treatment Plant
- Lockhart Wastewater Reclamation Division
- Panda Raw Water Delivery System
- San Marcos Raw Water Delivery System
- Rural Utilities Division
- Canyon Hydroelectric Division
- Guadalupe Valley Recreation
- Guadalupe Valley Hydroelectric Division

There are two primary alternatives for organizing the operations for the new facilities comprising the Regional Water Supply Project, which can be summarized as follows:

- Absorb the operations of the Regional Water Supply Project into one of the existing nine utility divisions
- Create a new operational division

Given the number and size of the facilities to be constructed under the Regional Water Supply Project, it may be feasible to propose that a new operating division (the Regional Water Supply Project Division) be established within the GBRA.

10.2.3 Regional Water Supply Project Facilities

The facilities to be constructed and operated by the GBRA under the project are currently proposed as follows:

Canyon Lake Raw Water Intake and Pump Station

- Floating intake and pump station
  - 2 duty pumps with 1 standby @ 700 hp each
- Electrical supply facilities
  - 2100 kva transformer and secondary supply
- Raw water chemical addition facilities
  - Potassium permanganate storage and feed
  - Off shore infrastructure
  - Electrical supply conduit/cable
  - Raw water pump discharge hoses
- Local control system and radio based telemetry and SCADA

Canyon Lake Raw Water Transmission System

- On shore valve vault to transition from off shore hose to pipeline
- Raw water transmission pipeline
  - Approximately 5 miles of 30-inch diameter pipe
  - 120,000 gallon storage tank at Startz Hill

Regional Water Supply Project Treatment Plant

- Pretreatment facilities (automatic strainers or solids contact clarifiers)
- Membrane filter system or Conventional dual media filters
- Granular activated carbon gravity filters
- Chemical additions facilities (chlorine, chlorine dioxide, membrane cleaning solution, coagulants, ferric, etc.)
- Finished water storage reservoir
- High service pump station with 2 duty pumps with VFD and 1 standby pump, each @ 250 hp
- Wash water flow equalization basins or lagoon
- Dissolved air flotation units or gravity thickener
- Sludge drying beds
- Washwater recycle pumping stations
- Local control system and main operator control station for telemetry and SCADA system

Regional Water Supply Project Transmission Pipeline

- Approximately 40 miles of treated water transmission pipeline
- Remote booster pump station, 6.5 mgd
- Up to 18 Customer connections consisting of metering and flow control valve vaults
- Local control at each customer site and radio based telemetry and

SCADA system

10.2.4 System Operational Areas

The successful operation of such a large system will require a well-organized operational approach. There are many operations areas needed. For the facilities described above, the following operational functions and areas have been identified:

<u>Management and Support Systems</u>

- Process control measurement and management
- Laboratory information, testing and TNRCC permit reporting
- Metering, billing, budgeting, accounting, water sales, contract management
- Instrumentation, SCADA, and communications
- Utilities (electrical, telephone, etc)
- Preventative maintenance program
- Chemical handling, inventory
- Safety practices and equipment, HAZMAT, emergency response plans
- Training
- Data and information management

<u>Equipment and Treatment Processes</u>

- Sampling of raw and finished water
- Equipment and treatment process operations

10.3 Level of Staffing

The GBRA is currently operating several similar facilities very successfully. As a result, there is a possibility that some of the above functions and operations areas could be absorbed into other GBRA groups without staff and facility additions. Only a portion of the above operations areas are covered by the staffing proposed. The level of staffing proposed covers the primary operations and maintenance of the facilities.

The following staffing level has been developed based upon our experience with similar facilities and meetings with GBRA staff:

- 1 Plant system manager
- 4 Full-time operators (for full 24 hour per day coverage)
- 1 Treatment plant mechanical maintenance technician
- 1 Electrical/instrumentation/SCADA technician
- 1 Pump station/customer response maintenance technician

The total number of staff required would be about the same for both treatment plant options. Once the operations and maintenance approach and strategy is in place, changes in raw water quality are usually the only occurrences which require a high level of operator treatment process oversight. The selected treatment process should minimize the required operator oversight and active process control needs during such occurrences, to best assure a consistently high quality finished water under all raw water quality conditions. Required operator training and certification levels are generally expected to reflect the anticipated process control complexity challenge.

10.4 Operations and Maintenance Costs

The following is preliminary operations and maintenance (O&M) cost opinion for the planned Regional Water Supply Project water treatment plant. The costs have been prepared for both treatment alternatives (membrane filtration and conventional) with GAC contactors. Cost opinions have been prepared for the anticipated start-up average daily flow (ADF) (10mgd, year 2001).

10.4.1 Membrane Filtration Alternative

Several key points from the O&M cost comparisons include:

- For the purposes of this report microfilters and ultrafilters present similar anticipated O&M costs. Cost differences between the two technologies are largely related to assumed membrane replacement costs, which may be considerably less costly than assumed (ie. longer membrane service lives than assumed) due to the normally high raw water quality and initially lower plant ADF.

- Electric power costs represent the largest O&M cost for all evaluated scenarios.

- Plant staffing is in accordance with the above

Results of these cost evaluations suggest an annual O&M cost of about **$0.65** per thousand gallons at the anticipated year 2001 ADF of 10mgd.

Major operations costs presented include power, chemicals, and operations labor. Major maintenance costs presented include membrane replacement and service, GAC replacement, mechanical systems service and replacement, and maintenance labor. O&M costs are based on current conceptual definition of the WTP system. While WTP system definition may be refined during final design, cost opinions presented are expected to adequately support GBRA's budgetary planning needs.

Cost Assumptions: The following assumptions are used to develop preliminary O&M costs:

- Electric power cost assumes $0.06/kW-hr. Potential power reduction options (peak avoidance, gas co-generation, etc.) not considered here.
- Chlorine cost assumes $500/ton.
- Caustic cost assumes $0.50/gal - 20% solution (recommended for emergency release scrubber system for chlorine gas).
- Operator labor assumes $22/hr (direct, overhead and benefits included).
- Maintenance labor assumes $25/hr (direct, overhead and benefits included).
- Supervisor labor assumes $41/hr (direct, overhead and benefits included).
- Annual repair/pro-rata replacement cost of mechanical equipment assumed to be 5% of equipment cost, unless noted otherwise.
- Membrane replacement costs assume manufacturer's recommended standard replacement life cycle. The lake high quality raw water and lower initial plant flows may both extend membrane service life, thereby reducing annual replacement cost.
- On-site regeneration of GAC is assumed for this cost opinion. Regeneration practices will be defined following pilot testing.
- Virgin GAC replacement is assumed at $1/pound

O&M Cost Opinions (Membrane Treatment Alternative)

Table 10-1: Year 2001 (10 mgd ADF) Facility - Membrane Filtration Plant Operation and Maintenance Costs

OPERATIONS	
Power Cost	**Annual Cost**
Raw Water Pumping (1400 HP)	634,500
RW PS Electrical Building Air Conditioning (4 tons) (KW)	2,100
Finished Water Pumping (500 HP)	163,500
Membrane Operations (backwash/unit power)	50,000
Misc Pumping/Mechanical (50HP)	19,700
Treatment Building (15,000 sf)	
-Heating (4months - 10 KW) (KW)	1,800
-A/C (6months - 10 tons) (KW)	9,300
-Lighting (2W/sf, 10hrs/day)	6,600
GAC Console Building (1000 sf)	
-Heating (4months - 1 KW)	900
-A/C (6months - 2 tons)	1,900
-Lighting (2W/sf, 10hrs/day)	400
GAC Filter and Reactivation Power	103,900

Power Cost (cont'd)	Annual Cost
DAF Units -Floatator drive, recycle pump, air compressor, etc @ 20 hp Decant Pump from Sludge Lagoons Washwater Recycle Pump	10,500 5,300 15,800
HS Pump Station Building (1,600 sf) -Heating (4months - 1 KW) -A/C (6months - 5 tons) -Lighting (2W/sf, 10hrs/day)	900 4,000 700
WTP outside area lighting (8kW, 10hrs/day)	1,800
Power Cost Subtotal:	**$1,033,600**
Membrane Operations Cost	**Annual Cost**
Membrane Chem Cleaning **Membrane Ops Cost Subtotal:**	13,000 **$13,000**
DAF Units	
DAF Chemical Coagulant Costs **DAF Unit Subtotal:**	23,000 **$23,000**
GAC Operations	
GAC Replacement (assuming 25% virgin replacement @ $1/lb) (463,000 lbs./yr.) Transfer and Process Water **GAC Operations Subtotal**	463,000 30,800 **$493,800**
Chlorination	
Chlorine Gas (1.5mg/l (avg.) – 23 tons/yr.) Caustic Replacement (once/year - 2k gal) Chlorine Dioxide (1.2 mg/L - 36,500 LB/yr.)	11,500 1,000 18, 300
Chlorination Cost Subtotal:	**$30,800**
Supervisor, Operations & Staff Labor	
Total Staff of 6	314, 100
Labor Cost Subtotal:	**$314,100**
Additional Supply Services and Insurance	**70,000**
Year 2001 (10mgd) Membrane Filtration Facility Operations Cost:	**$1,978,300**

MAINTENANCE	
Facilities	**Annual Cost**
Mechanical Pumping Systems	
- Repair / ProRata Replacement	50,000
Membrane System	
-Membrane Replacement (6-year cycle)	125,000 (a)
-Compressor System Repair / ProRata Replacement	2000
-Membrane Annual Service Agreement	1000
-Equipment Maintenance	20,000
Chlorination System	
-Repair / ProRata Replacement	10,000
DAF and Sludge Lagoon System	
- Repair / ProRata Replacement	37,500
Decant and Washwater Recycle Pumping System	
- Repair / ProRata Replacement	10,000
Bldg. Maintenance	
-General Bldg. / Mechanical Maint Costs	5,000
WTP Site Maintenance	
-General Grounds Keeping / Lighting Maint	15,000
Facilities Maintenance Cost Subtotal:	**$275,500**
Maintenance Labor	**Annual Cost**
-Maintenance Staff (2/day, 8hrs/day ea.)	$104,000
Maintenance Labor Cost Subtotal:	**$104,000**
Year 2001 (10mgd) Membrane Filtration Facility Maintenance Cost:	**$379,500**
Year 2001 (10mgd) Membrane filtration Facility Total O&M Cost:	**$2,357,800**
Equivalent O&M Cost/1000gal:	**$0.65**

(a) Membrane replacement cost and life cycle varies from supplier to supplier.

10.4.2 Conventional Treatment Alternative

Several key points from the O&M cost comparisons include:

- For the purposes of this report a conventional treatment plant consisting of solids contact clarifiers, dual media gravity filters and GAC contactors is used to determine anticipated O & M costs.
- Electric power costs represent the largest O&M cost for all evaluated scenarios.
- Plant staffing is in accordance with the above

Results of these cost evaluations suggest an annual O&M cost of about **$0.60** per thousand gallons at the anticipated year 2001 ADF of 10mgd.

Major operations costs presented include power, chemicals, and operations labor. Major maintenance costs presented include, GAC replacement, mechanical systems service and replacement, and maintenance labor. O&M costs are based on the conventional Alternative B system described in Chapter 8. While WTP system definition may be refined during final design, cost opinions presented are expected to adequately support GBRA's budgetary planning needs.

Cost Assumptions: The following assumptions are used to develop preliminary O&M costs:

- Electric power cost assumes $0.06/kW-hr. Potential power reduction options (peak avoidance, gas co-generation, etc.) not considered here.
- Ferric cost assumes $0.10/pound.
- Chlorine cost assumes $500/ton.
- Caustic cost assumes $0.50/gal - 20% solution (recommended for emergency release scrubber system for chlorine gas).
- Operator labor assumes $22/hr (direct, overhead and benefits included).
- Maintenance labor assumes $25/hr (direct, overhead and benefits included).
- Supervisor labor assumes $41/hr (direct, overhead and benefits included).
- Annual repair/pro-rata replacement cost of mechanical equipment assumed to be 5% of equipment cost, unless noted otherwise.
- On-site regeneration of GAC is assumed for this cost opinion. Regeneration practices will be defined following pilot testing.
- Virgin GAC replacement is assumed at $1/pound.

O&M Cost Opinions (Conventional Treatment Alternative)

Table 10-2: Year 2001 (10 mgd ADF) Facility – Conventional Treatment Plant Operation and Maintenance Costs

OPERATIONS	
Power Cost	**Annual Cost**
Raw Water Pumping (1400 HP)	634,500
RW PS Electrical Building Air Conditioning (4 tons) (KW)	2,100
Finished Water Pumping (500 HP)	163,500
Solids Contact Clarifiers	
-Clarifier Unit (2 HP)	800
-Recirculation Mixer (6 HP)	2,400
Conventional Filtration Operations (backwash, etc.)	50,000
-Backwash Pumping	1,600
-Air Scour Compressor	1,000
Misc Pumping/Mechanical (60HP)	23,700
Operations Building (4,200 sf)	
-Heating (4months - 4 KW)	700
-A/C (6 months - 7 tons)	6,500
-Lighting (2W/sf, 10hrs/day)	1,800
GAC Console Building (1000 sf)	
-Heating (4months - 1 KW)	900
-A/C (6months - 2 tons)	1,900
-Lighting (2W/sf, 10hrs/day)	400
GAC Filter and Reactivation Power	83,100
Gravity Thickener	
-Pump and skimmer @ 9 hp	4,700
Decant Pump from Sludge Lagoons	7,900
Washwater Recycle Pump	15,800
HS Pump Station (1,600 sf)	
-Heating (4months - 1 KW)	900
-A/C (6months - 5 tons)	4,000
-Lighting (2W/sf, 10hrs/day)	700
WTP outside area lighting (8kW, 10hrs/day)	1,800
Power Cost Subtotal:	**$1,010,700**
Operations Cost	**Annual Cost**
Coagulation	
Ferric (40 mg/L (avg.) – 1,220,000lb/yr)	122,000
Coagulation Subtotal:	**$122,000**
GAC Operations	
GAC Replacement (assuming 25% virgin replacement @ $1/lb) (370,400 lbs./yr.)	370,400
Transfer and Process Water	24,600
GAC Operations Subtotal	**$395,000**

Chlorination	
Chlorine Gas (1.5mg/l (avg.) – 23 tons/yr.) Caustic Replacement (once/year - 2k gal) Chlorine Dioxide (1.2 mg/L – 36,500 lb./yr.)	11,500 1,000 18,300
Chlorination Cost Subtotal:	**$30,800**
Supervisor, Operations & Staff Labor	
Total Staff of 6	314,100
Labor Cost Subtotal:	**$314,100**
Additional Supply Services and Insurance	**70,000**
Year 2001 (10mgd) Conventional Filtration Facility Operations Cost:	**$1,942,600**
MAINTENANCE	
Facilities	**Annual Cost**
Mechanical Pumping Systems	
- Repair / ProRata Replacement	50,000
Conventional System	
-Solids Contact Clarifier System Repair/ ProRata Replacement	33,000
-Filter Media Replacement / ProRata Replacement	5,000
-Equipment Maintenance	15,000
Chlorination System	
-Repair / ProRata Replacement	10,000
Thickener System	
- Repair / ProRata Replacement	12,500
Decant and Washwater Recycle Pumping System	
- Repair / ProRata Replacement	10,000
Bldg. Maintenance	
-General Bldg. / Mechanical Maint Costs	5,000
WTP Site Maintenance	
-General Grounds Keeping / Lighting Maint	15,000
Facilities Maintenance Cost Subtotal:	**$155,500**
Maintenance Labor	**Annual Cost**
-Maintenance Staff (2/day, 8hrs/day ea.)	$104,000
Maintenance Labor Cost Subtotal:	**$104,000**
Year 2001 (10mgd) Conventional Filtration Facility Maintenance Cost:	**$259,500**
Year 2001 (10mgd) Conventional Filtration Facility Total O&M Cost:	**$2,202,100**
Equivalent O&M Cost/1000gal:	**$0.60**

Regional Water Supply Project for Portions of Comal, Kendall, and Bexar Counties

Facilities Plan

Technical Memorandum

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11. Facilities Plan

11.1 Introduction

The purpose of this technical memorandum is to present preliminary facilities plans and building architectural features for the treatment plant options. Preliminary plans (figures) have been prepared for both a conventional and a microfiltration/ultrafiltration (MF/UF) membrane water treatment plant. The site plans are general since a specific location has not been selected. Once a treatment plant site and treatment technology is selected, the preliminary layouts will be updated to include ground contours, topographic features, roads, treatment structure dimensions and elevations.

11.2 Membrane Treatment Plant Structures & Site Plan

Figure 11.1 is a preliminary floor plan of the membrane building. This building size is estimated at 75 feet wide by 220 feet long. This building option includes a membrane treatment equipment area, chemical feed area, office, laboratory, work shop, electrical and control rooms and other associated rooms/areas. The final size of the building will be revised based on the specific membrane manufacturer selected and GBRA operation and maintenance requirements. See section 11.6 for additional floor plan options.

A preliminary layout was prepared for the granular activated carbon (GAC) contactors. Figure 11.2 is a top plan of the GAC structure. The size of the GAC filters/contactors structure is estimated at 45 feet wide by 100 feet long. This plan also indicates the area required for two additional filters to increase plant capacity to 15 million gallons per day (MGD). A small building (20 feet wide by 45 feet long) is located above the structure for the filter consoles. Depending on site elevations, plant hydraulic and filter gallery piping/equipment access requirements, the GAC structure could be partially buried or all above ground. This preliminary plan assumes the top of the structure is 10 feet above the surrounding ground.

Figure 11.3 is a preliminary site/piping plan for the membrane treatment plant. Major features include the membrane building, GAC contactors, 2 million gallon treated water reservoir, high service/backwash supply pumping station and residuals system. Once a plant location is selected, a more detailed site plan will be prepared. Site layout for plant components will take into account the following variables:

- Type of site soils, excavation requirements and constructability
- Depth to groundwater
- Environmental impacts (tree removal, etc.)
- Local zoning regulations, OSHA and building code requirements
- Plant hydraulic requirements (gravity vs. pumped systems)

- Location relative to existing roads and utilities (electricity, telephone, gas, sewer, etc.)
- Traffic flow, access requirements for construction and operation and maintenance trucks/equipment
- Climate (sun orientation, wind, rainfall, etc.)
- Slope of land and earthwork requirements (excavation and backfill)
- Site storm drainage runoff
- Drainage of plant emergency overflow water
- Operator safety and the safety of future neighboring homes and/or businesses
- Providing a land area buffer zone for noise and potential odors
- Provisions for future plant expansion and new treatment technologies
- Locating pipelines for easy access and maintenance
- Providing adequate area for construction activities
- Site security from theft and vandalism
- Building aesthetics relative to public view
- Landscaping requirements
- Construction and land costs

Plant land area requirements vary based on treatment process selected, site elevations, excavation and land buffer requirements. Plant site area could very between 10 to 20 acres. Ideally the selected site will have at least a 25-30 foot change in elevation. This elevation difference will reduce the amount of major excavation and pumping required.

11.3 Conventional Treatment Plant Structures & Site Plan

As indicated in Technical Memorandum No. 8, Treatment Technology Evaluations, there are potentially many types of conventional plants that could be constructed for this project. The types that utilize solids contact clarifier equipment have smaller land area requirements compared to a conventional treatment plant with rapid mix, flocculation and sedimentation basins. Two solids contact clarifiers are required for the initial 10-mgd plant. A typical solids contact clarifier is shown on figure 11-4. Each clarifier would be 85 ± foot diameter with a side water depth of about 17 feet. A conventional dual media gravity filter is shown on figure 11-5. The filter would be similar in construction to the GAC contactors with approximate dimensions of 42 feet by 100 feet. Land area and stub outs are provided for future filter(s).

Figure 11.6 is a preliminary site/piping plan for a conventional treatment plant. Major features include the solids contact clarifiers, dual media gravity filters, GAC contactors, 2 million-gallon treated water reservoir, chemical feed building, operations building, high service/backwash supply pumping station, flow equalization basins and residuals system.

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