FINAL MEMORANDUM

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FROM: Jason Afinowicz & Spandana Tummuri

SUBJECT: Supply Scenario Evaluation (Task 1103)

DATE: 2017/12/08

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Introduction

The San Jacinto River Authority (SJRA) retained Freese and Nichols, Inc. (FNI) to develop a raw water supply master plan (RWSMP) study of Highlands Division and Lake Conroe Division which, in turn, serves the Groundwater Reduction Plan (GRP) and The Woodlands Divisions. This RWSMP study consists of four components:

- Evaluation of Demand Scenarios
- Evaluation of Supply Scenarios and Needs
- Preliminary Strategy Identification and Evaluation
- Strategy Evaluation and Selection

The purpose of this technical memorandum is to summarize the approach used for supply evaluation and discuss the evaluation of available supplies in order to determine future water needs. This analysis is divided between the Highlands service area and Montgomery County service area. SJRA's Montgomery County service area includes the current and potential future Groundwater Reduction Program (GRP) Participants. SJRA's Highlands service area includes various industrial, irrigation, and municipal customers in the eastern Harris County. The primary purpose of the supply scenario evaluation was to determine the reliability and availability of the existing supplies permitted by SJRA. *Table 1* provides a list of supply sources currently permitted and owned by SJRA.

Table 1 - Summary of Supply Sources Permitted and Owned by San Jacinto River Authority

Number	Source Name	Water Right Number	Supply Volume (Acre-Feet per Year)	River Basin	Service Area
1	Lake Conroe[1]	WR-4963	100,000	San Jacinto	Montgomery
2	SJRA Highlands Permit	WR-4964	55,000		Highlands
3	Lake Houston Additional Authorization (SJRA Portion)	WR-5807	14,100		
4	SJRA Lake Houston Excess Flow Permit	WR-5808	80,000		
5	SJRA Lake Houston Reuse Permit	WR-5809	14,944		
6	SJRA Devers Run-of-River Right	WR-5271	56,000	Trinity	
7	SJRA CLCND Run-of-River Right	WR-4279A	30,000		

1 SJRA owns 1/3rd of Lake Conroe supplies, i.e. 33,333 acre-feet. It is assumed that the full amount is available to them by means of a contract with City of Houston.

Supply Evaluation

For general planning and permitting purposes, available supplies are tracked on an annual basis. Since demands projections are also reported on an annual time-step, the annual available supplies can be compared against the annual demands to determine the annual shortages or needs. However, there are some hydrological and policy conditions that impact the timing of the supply availability within a given year. A source of supply may seem to meet/match the projected demands on an annual basis but there may be certain months during which the monthly demands cannot be met by the monthly volume of supplies available. This concept is presented in *Figure 1* by means of an example illustration. This issue was addressed in the supply evaluation process by means of two steps: 1) the available supplies were determined after applying the impact of some known risk variables that would impact the availability 2) a detailed operations model was developed to compare the supplies and demands on a monthly time-step and determine the needs/shortages on a sub-annual time-step. The remainder of this technical memorandum is a summary of these steps and the supply evaluation process.

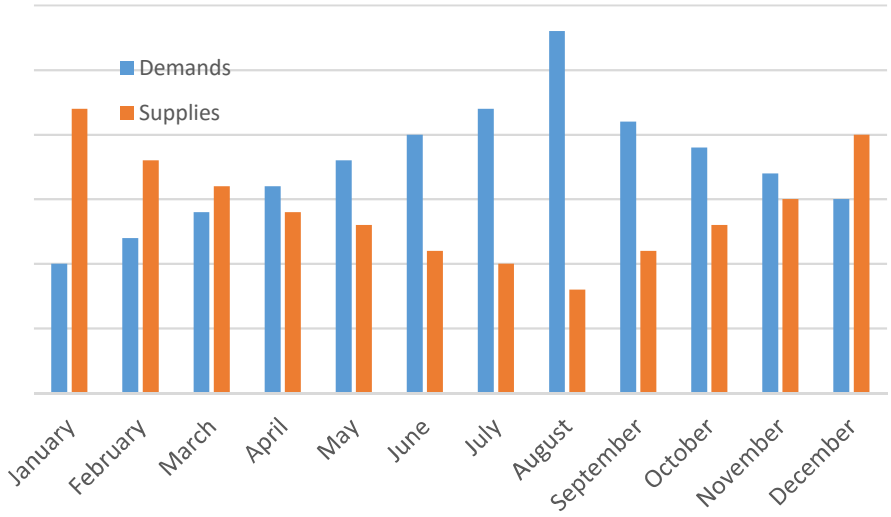


Figure 1 - An Illustration representing a hypothetical timing of the Supply and Demand Availability

Supply Availability Modeling Scenarios

The resiliency or reliability of the permitted supplies in river basins throughout the state of Texas is determined by means of Water Availability Models (WAMs). Texas Commission of Environmental Quality (TCEQ) maintains WAMs based on Water Rights Analysis Program (WRAP) for various river basins in the state. These WAMs simulate the assignment of water supplies based upon the water rights priority system. The San Jacinto and Trinity River Basin WAMs were used in this study as SJRA owns supplies in those two basins.

Two versions of the WAMs are currently maintained by TCEQ and reflect different supply conditions. The Run3 WAMs reflect the original design curves for reservoir sedimentation conditions and do not include the availability of any potential return flows in the river basin. The Run8 WAMs reflect the current reservoir sedimentation conditions but also include the potential for all the return flows that could originate in the river basin. For the purpose of this study, the Run3 WAM was selected as the base model and modifications were made to the Run3 base WAM model to analyze various risk variables impacting the supply availability. In other words, the Run3 base WAM was modeled without modification as an independent **baseline scenario**.

In addition to the priority system and current reservoir conditions, the future availability of existing supplies in a river basin may be impacted by certain risk variables. While it is impossible to determine every possible risk variable that may impact future availability, certain known risk variables impacting the water supply were identified for the purpose of the study. This study considers three known risk variables: 1) Reservoir Sedimentation 2) Return Flows and 3) Uncertainty.

Potential reservoir sedimentation in the future decades may fundamentally impact the supply availability in the river basins. The base Run3 WAM model does not account for the future reservoir sedimentation conditions. Therefore, the base WAM was adjusted to incorporate the potential future sedimentation and this was modeled as an independent scenario, **decadal base sedimentation-only scenario**.

Potential return flows resulting from the future growth in the watersheds contributing to the river basins were also not accounted for in the Run3 base WAM. Analysis of the population projections and the demand estimates evaluated in Task 2 of this study indicated a potential for significant return flows contributing to the river basins. The magnitude of these return flows increase incrementally in the future.

The underlying hydrological assumptions in the Run3 WAM are based on the hydrological conditions from known period-of-record events. This known period-of-record (1940-1996) includes both dry and wet events from the recorded historical period, including the critical drought of the record. When modeling the future demand conditions against the known hydrologic period-of-record, the assumption is that the future hydrologic events would repeat the hydrologic events from the known past. However, some recent, extreme events indicate that the future hydrology may or may not be adequately represented by the known period-of-record events. A sound approach for planning for future supplies must consider this potential uncertainty in the representation of the future hydrology.

Upon detailed evaluation of the known risk variables, it was determined that the most probable representation of the future supplies would not be driven by the impact of individual risk variables alone, but may be impacted by the combination of the known risk variables. Therefore, an additional scenario was analyzed to include the impact of sedimentation, availability of return flows, and potential uncertainty in hydrological conditions. This scenario was termed as the **expected conditions scenario**.

Table 2 summarizes the various scenarios considered for the supply evaluation.

Table 2 - Summary of the Supply Scenarios Considered for Evaluation

Scenario	Scenario Name	Description
1	Base	Run3 WAM Model
2	Base Sedimentation	Run3 WAM Model adjusted to include future sedimentation
3	Expected Conditions	Run3 WAM model adjusted to include the impact of future sedimentation, return flows, and hydrological uncertainty

Supply Modeling Time Periods

The long-range raw water supply plan focuses on the demand-supply evaluation for the five-decade period ranging from 2020-2070. This time period coincides with the availability of population projections and the time period considered for the state of Texas regional water planning process. In order to span this period, supply evaluation was conducted for three decadal points reflecting the near-term (2020), mid-term (2040), and long-term (2070) periods.

Risk Variables

Three risk variables were considered to impact the availability of SJRA's existing supplies. These variables are 1) Sedimentation, 2) Return Flows, and 3) Hydrological Uncertainty. A detailed discussion of the risk variables is included in *Attachment A* of this memorandum.

Water Supply Modeling Scenarios

Based on the assumptions presented above, the following model scenarios listed in *Table 3* were considered in the raw water supply master plan:

Table 3 – Summary of the Water Supply Modeling Scenarios Selected for Evaluation

WAM	Model	Sedimentation	Return Flows	Uncertainty
SAN JACINTO WAM & TRINITY WAM	Base	None	None	None
	Decadal Base 2020	2020	None	None
	Base 2020 Expected	2020	2020	2020
	Decadal Base 2040	2040	None	None
	Base 2040 Expected	2040	2040	2040
	Decadal Base 2070	2070	None	None
	Base 2070 Expected	2070	2070	2070

Results of Supply Evaluation

Supply Availability (Firm Yield Estimates using WAM Models)

The firm yield availabilities for various SJRA water rights in the San Jacinto and Trinity River Basins were determined by means of the water supply models described above. The firm yield is described as the amount of supply that is reliably available to SJRA in case of the repeat of the dry conditions similar to the critical drought-of-record. *Figure 5* includes a summary of the firm yield supplies in the Montgomery County system. Lake Conroe is currently the only source of SJRA supply to the Montgomery County System. The permitted supply from Lake Conroe is 100,000 acre-feet per year. It can be noted that all the water supply modeling scenarios resulted in firm yield availability less than the maximum permissible yield for Lake Conroe. Of these scenarios, the potential availability is the greatest

for the 2020 expected conditions scenario, resulting in approximately 86,000 acre-feet per year of available supply. *Figure 6* includes a summary of all SJRA water rights in the Highlands system. It must be noted that SJRA's Highlands permit is backed up by the City of Houston supplies in Lake Houston. SJRA's excess flow permit does not yield any supply as the WAM modeling is based on the yield availability in drought conditions which does not coincide with the periods when excess flows are available for use in the flood pool. Maximum supplies are available for 2040 and 2070 expected conditions scenarios. *Table 4* includes a detailed summary of the available yields for SJRA water rights in the Montgomery County and Highlands systems for various water supply modeling scenarios.

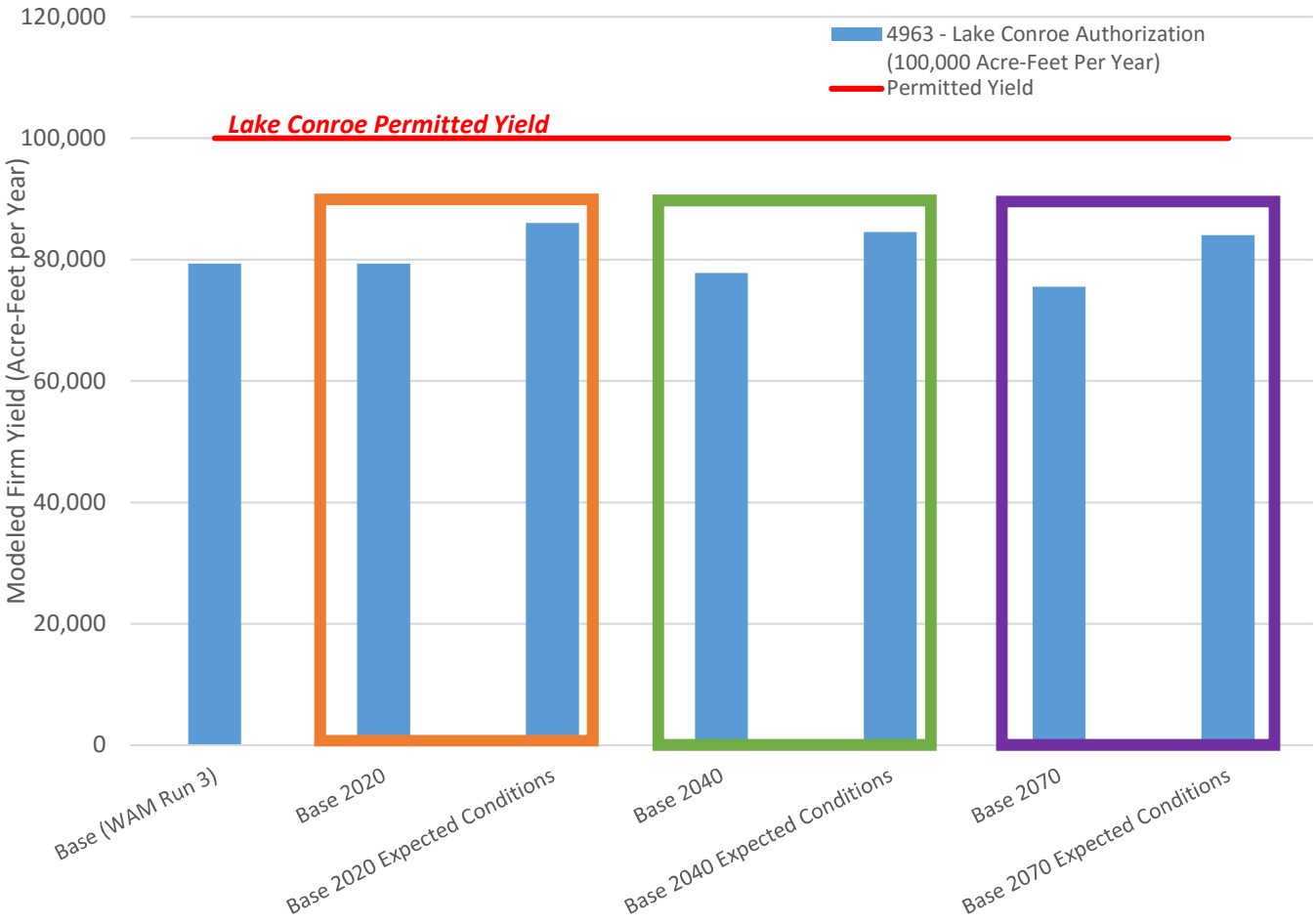


Figure 5 – Summary of Lake Conroe Yield (Montgomery County System) for Various Water Supply Modeling Scenarios

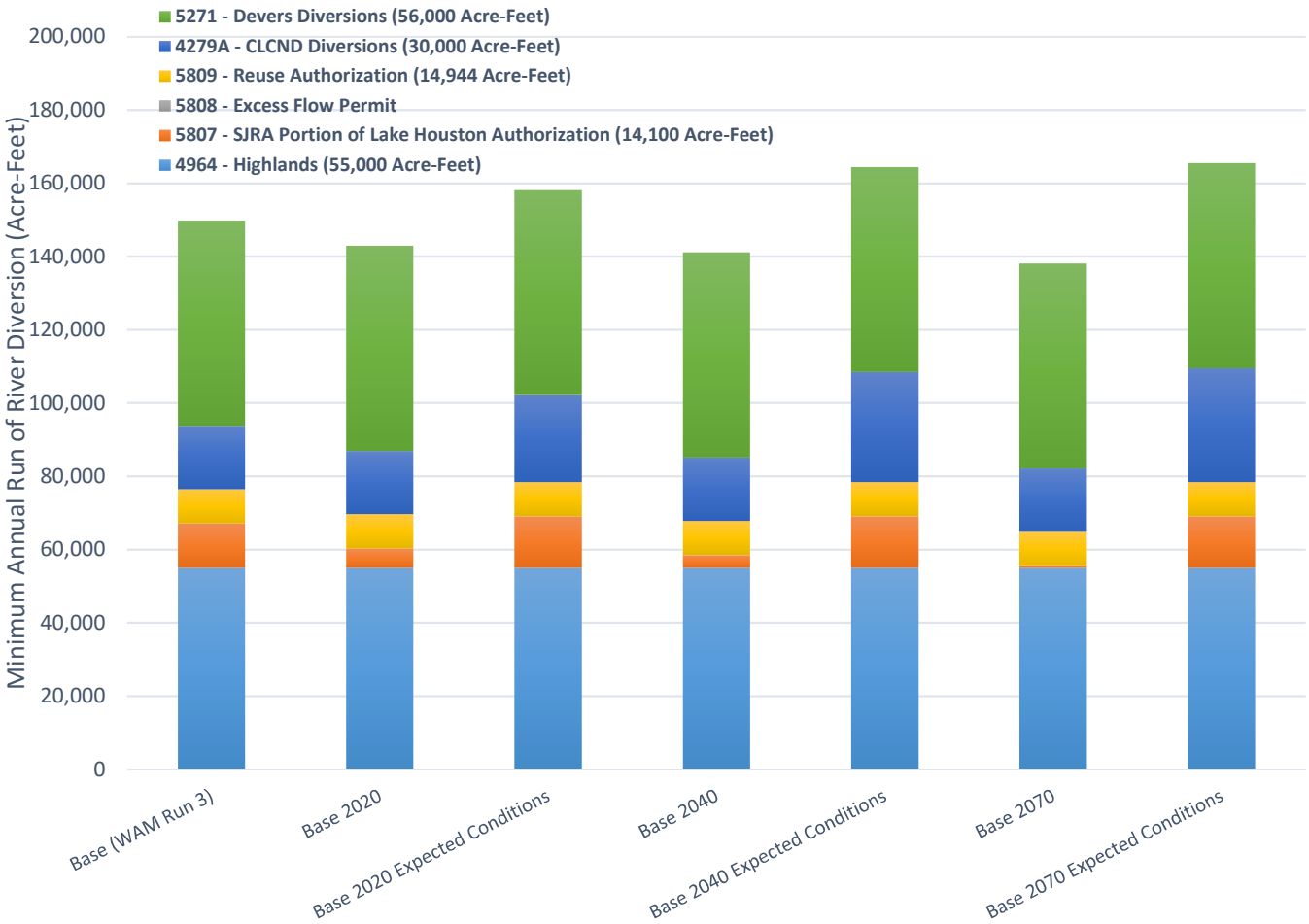


Figure 6 – Summary of SJRA Water Rights in Highlands System for Various Water Supply Modeling Scenarios

Table 4 – Detailed Summary of the Available Yields for SJRA Water Rights in Montgomery and Highlands System

MODEL RUNS WITH MULTIPLE DEMAND SCENARIOS												
Model	Reservoir Sedimentation	Return Flows	Uncertainty	Available Yield (Acre-Feet/Year)								
				Highlands							Lake Conroe Total (4963)	Lake Houston (4965)[1]
				Highlands (4964)	SJRA (5807)	Excess Flow (5808)	SJRA Reuse (5809)	CLCND (4279A)	Devers (5271)	Highlands TOTAL		
Base (WAM Run 3)	None	None	None	55,000	12,100	0	9,344	17,336	56,000	149,780	79,300	117,417
Base 2020	2020	None	None	55,000	5,300	0	9,344	17,289	56,000	142,933	79,300	117,400
Base 2020 Expected Conditions	2020	2020	2020	55,000	14,100	0	9,344	23,716	56,000	158,160	86,000	122,295
Base 2040	2040	None	None	55,000	3,500	0	9,344	17,289	56,000	141,133	77,794	117,400
Base 2040 Expected Conditions	2040	2040	2040	55,000	14,100	0	9,344	30,000	56,000	164,444	84,500	134,619
Base 2070	2070	None	None	55,000	500	0	9,344	17,289	56,000	138,133	75,500	117,400
Base 2070 Expected Conditions	2070	2070	2070	55,000	14,100	0	9,344	31,080	56,000	165,525	84,000	144,080

1. Lake Houston is not a direct source of supply for SJRA Montgomery County or Highlands systems but the firm yield of the Lake was included in this table as these supplies act as a backup to SJRA's Highlands permit 4964.

Needs Analysis

The water supply modeling resulted in a summary of firm yield availability or the reliability of all the SJRA supplies in the event that dry conditions similar to the critical drought of record reoccurred in the future. The future reliability of supplies was determined for the base Run3 WAM, decadal base sedimentation, and decadal expected conditions (includes decadal return flows, less impacts from decadal uncertainty) assumptions. The firm yields were reported as annual availabilities. While the annual availabilities serve as good indicators of the reliability of SJRA's available supplies, they are not reliable proxies of supply available for diversions. Water supply diversions occur on sub-daily, daily, and monthly time-steps. What seems like a reliable supply on an annual basis may not translate into a reliable supply when analyzed on a monthly or daily time-step. A big picture study, such as the Region H regional water plan, can focus on the annual volumes to develop a general understanding of the regional availabilities and potential shortages. Entity-specific studies, such as this one, have to focus on a more detailed level evaluation of supply availability and determine the reliability based on the detailed study.

Planning for future supplies is a complex process involving multiple unknowns. It is always unclear how the demand patterns manifest during the planning horizon. It is also unclear how hydrology will impact the supply availability. The most reasonable approach for accounting for the unknowns is to model multiple combinations of the future supply and demand scenarios and develop a strategy profile after evaluating the results from the various supply and demand comparisons. In this study, the long-term planning process was based on the needs estimated for the worst-case demand and supply scenarios. However, additional supply and demand scenarios were evaluated and they serve to frame the context and variability in the supply and demand availability.

Operations Model

A monthly needs analysis was conducted using an operations model developed using the software program STELLA. STELLA is a decision support system model that was used to develop a monthly SJRA operations model. STELLA is not a dedicated hydraulic model or reservoir operations model or priority-based water accounting program but is a general decision support tool that may be employed to answer questions and optimize processes. The program is well suited for developing decision support models for planning purposes and its features allow the user to represent an entity's supply, demand, and delivery system including the constraints and capacity limitations that drive the system operations. The program can be used to easily conduct multiple supply and demand scenario evaluations. The program also helps determine the monthly timing and location of the needs. The user also has a flexibility to incorporate need-specific strategies to address the needs in different portions of the entity's service area.

An operations model was developed for SJRA's Montgomery County and Highlands service areas. Using this operations model, a monthly needs analysis was conducted to develop a detailed balance sheet of the supply availability and the demand potential.

Both the Montgomery County and Highlands systems were represented in the operations model. Two demand scenarios selected for the Highlands system and the three demand scenarios selected for the Montgomery County system were populated in the model. The user has the capability of selecting any one of the demand scenarios for modeling purposes. The operations model included Lake Conroe, Lake Houston, and Highlands Reservoir. Inflows to Lake Conroe and Lake Houston were obtained from the Run3 WAM model. No storage was considered in Highlands Reservoir and it was modeled as a pass-through system. Lines delivering municipal demand to the east and south portions of the Montgomery County system were modeled along with the take points for the industrial

and irrigation demands. The canal system conveying flows in the Highlands system was modeled along with appropriate capacity constraints and interconnections. Strategy evaluation using operations model is not part of the current study but it may be incorporated as part of any of the future phases.

Three supply scenarios were considered for the needs analysis in the operations model: 1) decadal base scenario 2) expected conditions (includes future return flows, sedimentation, and uncertainty), and 3) drought contingency scenario. The decadal base scenario serves as the basis for estimating SJRA's future needs for the planning period. However, the expected conditions and the drought contingency scenarios serve as the plausible variations that could potentially occur. The range of these alternative scenarios is intended to bracket the range of potential outcomes. While the expected condition results in supplies greater than the decadal base scenario (mainly owing to the return flows from the contributing watersheds), the drought contingency scenario results in demands less than the demands used in the study. The net effect of either of these alternative scenarios is a reduced level of projected need.

Demand scenarios were developed as a combination of industrial, irrigation, and municipal demand projections. Two demand scenarios were recommended for Highlands system and three demand scenarios were recommended for Montgomery County system. *Tables 5 and 6* below summarize the demand scenarios selected for this study and those used for the needs analysis.

Table 5 – Recommended Demand Scenarios for Highlands System

System	Demand Scenario	Industrial Projection	Irrigation Projection	Municipal Projection
Highlands	1	(2) Expanded Contracts	(1) Current Contracts	(1) Current Contracts
Highlands	2	(4) Expanded Contracts + Region H Growth	(1) Current Contracts	(2) Current Contracts + Region H Growth

Table 6 – Recommended Demand Scenarios for Montgomery County System

System	Demand Scenario	Industrial Projection	Irrigation Projection	Municipal Projection
Montgomery	1	2) Expanded Contracts	(1) Current Contracts	(4) RGUP Pop + Region H GPCD + Region H Manufacturing
Montgomery	2	2) Expanded Contracts	(1) Current Contracts	(6) RGUP Pop + Region H GPCD + Region H Manufacturing + Baseline Conservation
Montgomery	3	2) Expanded Contracts	(1) Current Contracts	(8) RGUP Pop + Region H GPCD + Region H Manufacturing + SJRA Conservation

Drought contingency triggers for the Montgomery County and Highlands systems were previously developed as part of the SJRA's Drought Contingency Plan (DCP) update. The drought triggers established in the DCP were adopted for the evaluation in this study. The drought triggers used for the Montgomery County and Highlands systems are summarized in *Tables 7* and *8* below. A summary of the supply and demand scenarios considered for the needs analysis are summarized in *Tables 9* and *10* for Montgomery County and Highlands systems respectively.

Table 7 - SJRA Montgomery County System Drought Triggers

Drought Stages	Conroe Trigger Elevation	% Municipal Demand Reduction	% Municipal Winter Demand Reduction	% Industrial Demand Reduction	Storage	% Storage
Stage 1	199	0%	0%	0%	368,744	91%
Stage 2	197	10%	5%	0%	333,407	82%
Stage 3	194	20%	10%	5%	284,109	70%
Stage 4	190	30%	15%	30%	225,933	56%

Table 8 - SJRA Highlands System Drought Triggers

Drought Stages	Lake Houston Trigger Elevation	% Municipal Demand Reduction	% Municipal Winter Demand Reduction	% Industrial Demand Reduction	Storage	% Storage	Trinity Romayor Gage Trigger
Stage 1	43	0%	0%	0%	104,508	88%	< 1,000 cfs
Stage 2	42	10%	5%	0%	94,627	79%	< 1,000 cfs
Stage 3	40	20%	10%	5%	74,866	63%	-
Stage 4	38	30%	15%	30%	60,579	51%	-

Table 9 - Supply and Demand Scenarios considered for the Needs Analysis (Montgomery County System)

Number	Service Area	Supply Scenario	Demand Scenario
1	Montgomery County	Decadal Base	Scenario 1
2			Scenario 2
3			Scenario 3
4		Expected Conditions	Scenario 1
5			Scenario 2
6			Scenario 3
7		Drought Contingency	Scenario 1
8			Scenario 2
9			Scenario 3

Table 10 - Supply and Demand Scenarios considered for the Needs Analysis (Highlands System)

Number	Service Area	Supply Scenario	Demand Scenario
1	Highlands	Decadal Base	Scenario 1
2			Scenario 2
3		Expected Conditions	Scenario 1
4			Scenario 2
5		Drought Contingency	Scenario 1
6			Scenario 2

Needs Analysis Results

The results from the needs analysis are discussed below. The supplies and demands were computed on a monthly time-step to identify the possible monthly shortages. The monthly volumes of supplies, demands, and shortages were converted to annual volumes to determine and compare the needs identified for various scenarios.

Montgomery County System Needs

Figures 7a, 7b, and *7c* include comparison of the annual volumes of supplies, demands, and shortages for Montgomery County system for the decadal base supply scenario. This particular scenario is a comparison of the decadal base supply scenario and the scenario 1, 2, and 3 demand conditions. It must be noted that scenario 1 demand condition is the worst-case demand scenario, followed by scenarios 2 and 3 respectively. For the decadal base supply scenario, there were no needs manifested in 2020 for all three demand scenarios. The 2040 needs ranged from 50,087 ac-ft per year (demand scenario 1) to 19,525 ac-ft per year (demand scenario 3). The 2070 needs ranged from 179,113 ac-ft per year (demand scenario 1) to 60,367 ac-ft per year (demand scenario 3). Since the decadal base scenario was being used for identifying needs and strategy determination, SJRA system needs were determined based on the results for the decadal base scenario.

Figures 8a, 8b, and *8c* include the comparison of the annual volumes of supplies, demands, and shortages for the expected conditions scenario. The magnitude of supplies was higher in the expected conditions supply scenario

compared to the decadal base scenario. This has a small positive impact on the needs and results in reduced needs for the Montgomery County system. The Montgomery County system does not show any needs in 2020. The 2040 needs range from 52,089 ac-ft per year (demand scenario 1) to 21,527 ac-ft per year (demand scenario 3). The 2070 needs range from 170,615 ac-ft per year (demand scenario 1) to 51,869 ac-ft per year (demand scenario 3). It should be noted that the expected conditions scenario analysis was performed to capture the "what if" scenario of the potential supply scenario. The fundamental assumption for the expected conditions scenario analysis was that the return flows, sedimentation, and uncertainty conditions may occur to a certain extent and, therefore, relieve the needs slightly. However, it is recommended that the results for the expected conditions scenario be used only as a guide for what may potentially happen rather than the basis for long-term planning as these crucial return flows cannot be committed to the enhancement SJRA's water supplies without being incorporated into a water management strategy such as indirect return flows.

Another option for reducing the needs was to consider a drought contingency scenario. The drought triggers are set in place to help entities prepare for the unexpectedly dry conditions manifested during extreme dry hydrological conditions. Implementation SJRA's drought contingency plan could help reduce the demands to a certain extent and, thus, reduce the needs by the proportional amount. Actual benefits of drought contingency are dependent upon the efficacy of the measures, user compliance, and the degree of drought impact. While it is not prudent to use the drought contingency scenario as the basis for long-term planning purposes, it helps to understand the impact of the reduced demands on the overall system needs.

Figures 9a, *9b*, and *9c* include the Montgomery County system needs for the drought contingency operational scenario and various demand scenarios. It was noted that the reduced demands resulted in 2040 needs in the range of 32,368 ac-ft per year (demand scenario 1) and 21,527 ac-ft per year (demand scenario 3). Similarly, the 2070 needs were in the range of 141,492 ac-ft per year (demand scenario 1) to 41,027 ac-ft per year (demand scenario 3).

The summary of the needs based on decadal base, expected conditions, and drought contingency supply scenarios and the worst case demand scenario for Montgomery County system are included in *Figure 10*. The needs presented in these *Figures* will be used for strategy evaluation in SJRA's raw water master plan. *Tables 10-12* include the summary of the needs analysis for the Montgomery County system.

In summary, it was observed that the expected conditions and drought contingency operational scenarios do provide some relief on the Montgomery County system needs over the decadal base scenario. However, the two scenarios cannot be reasonably counted upon as the basis for the long-term plan. The supplies, demands, and needs from the decadal base scenario were chosen as the basis for the long-term planning and strategy evaluation for the SJRA Montgomery County system.

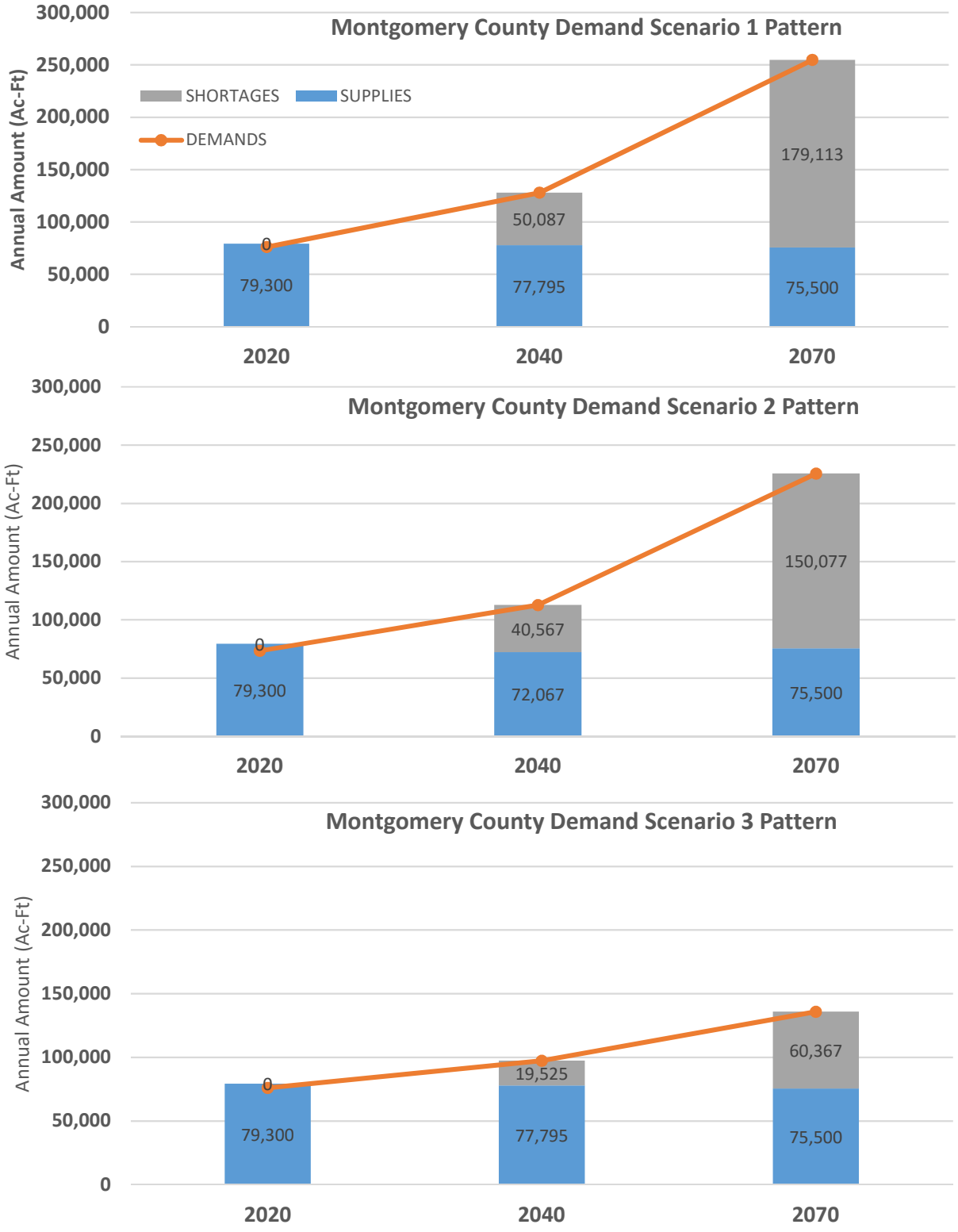


Figure 7a, 7b, and 7c – Needs summary for Montgomery System for decadal base supply scenario and various demand patterns

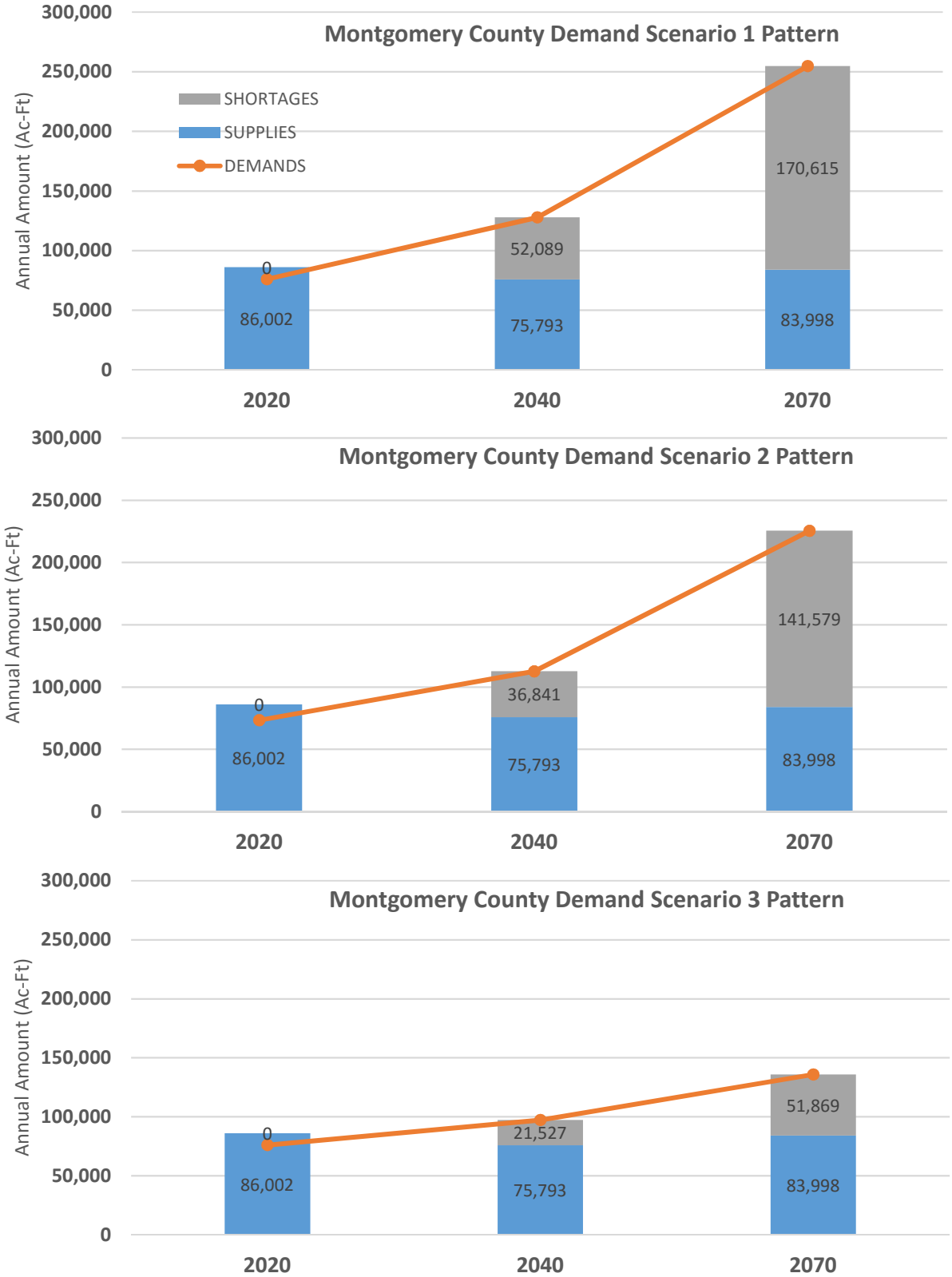


Figure 8a, 8b, and 8c - Needs summary for Montgomery System for expected conditions scenario and various demand patterns

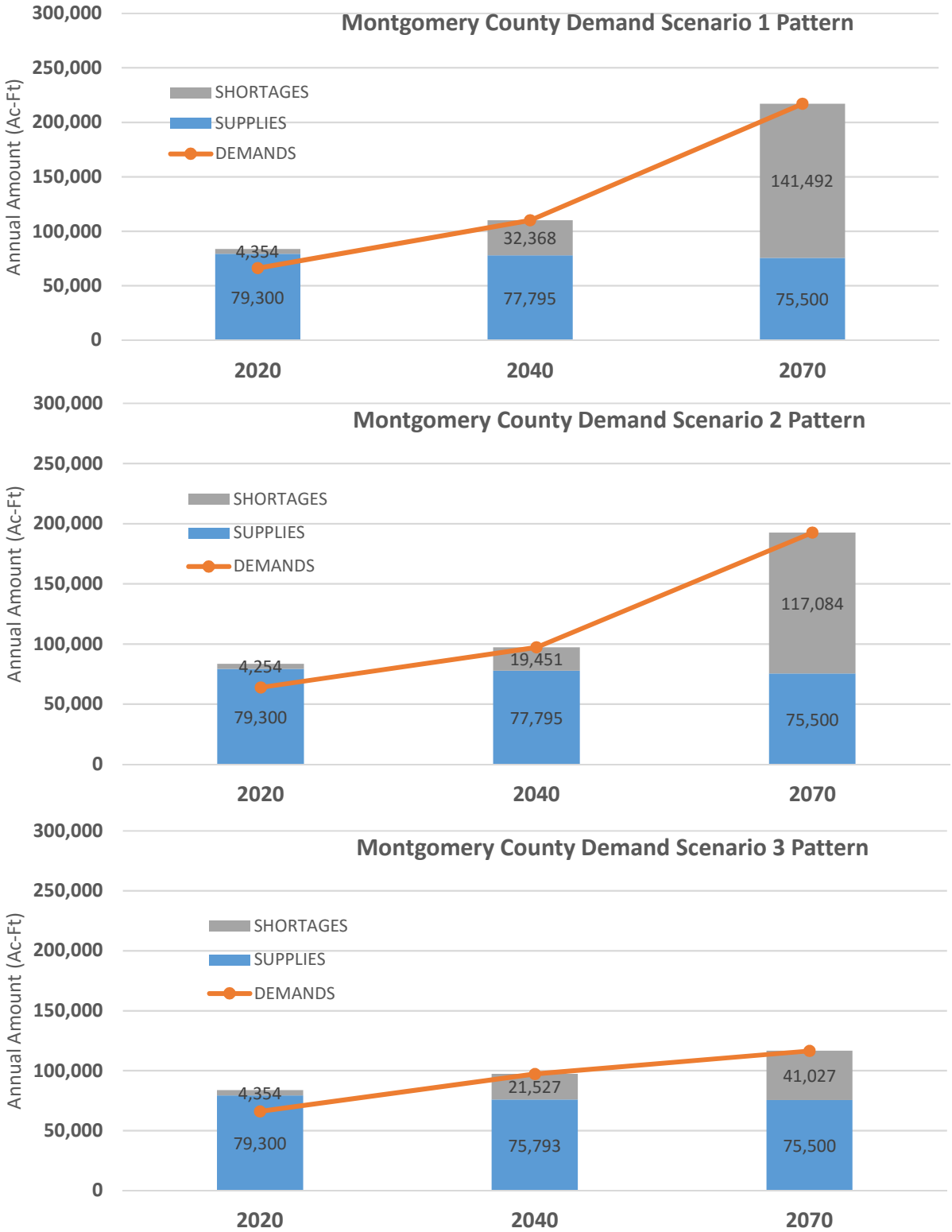


Figure 9a, 9b, and 9c – Needs/Shortages summary for Montgomery County System for drought contingency scenario and various demand patterns

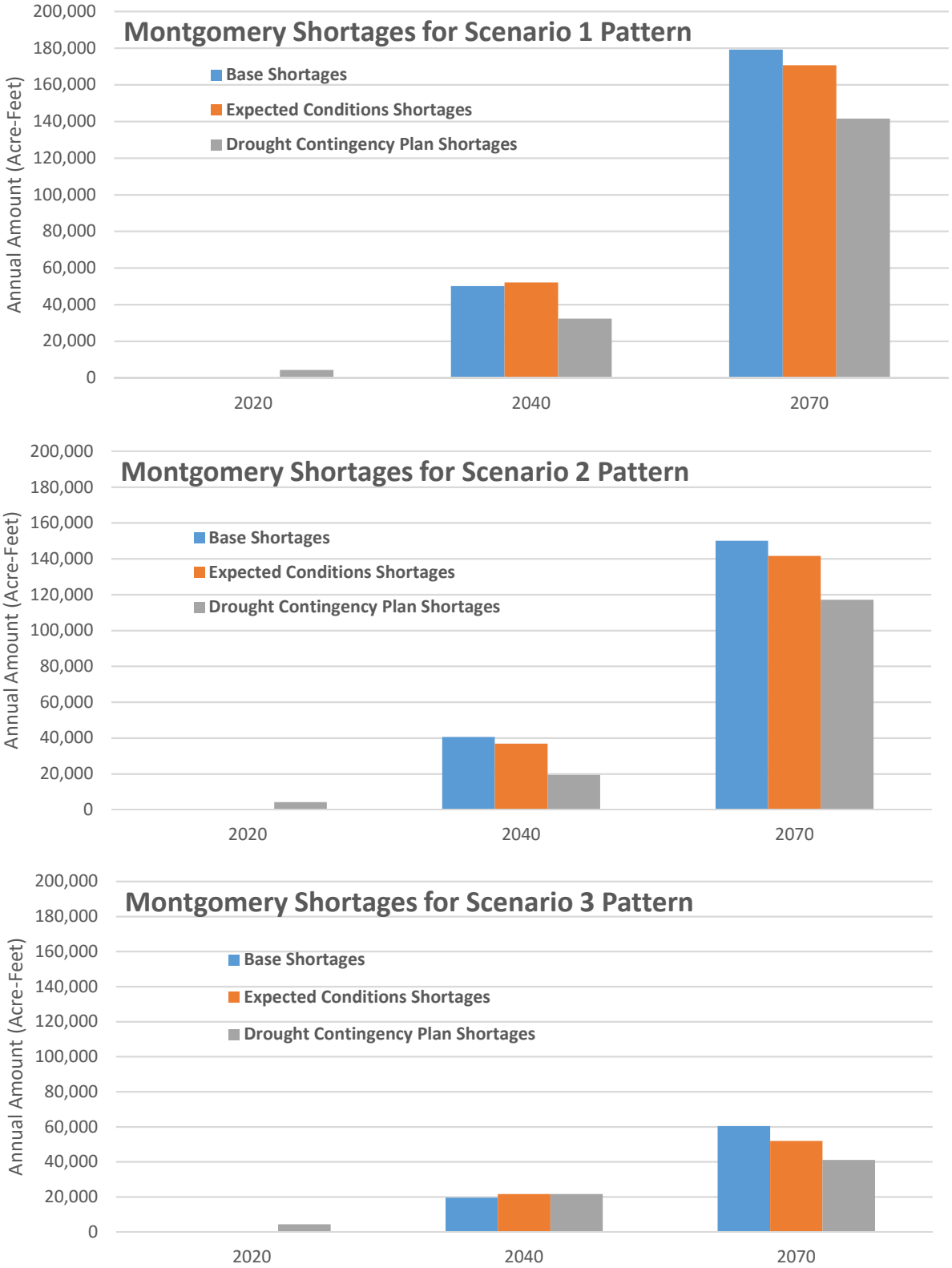


Figure 10 – Summary of overall needs/shortages in SJRA's Montgomery County System for three demand patterns evaluated

Highlands System Needs

Figures 11a and *11b* include the results of the needs analysis conducted for the decadal base supply scenario and the two demand scenarios selected for the Highlands system. The demands were well within the range of the supplies available and there were very minimal needs identified for the three planning time frames chosen for this analysis (2020, 2040, and 2070). On an annual basis, there were more supplies in the Highlands system than the overall annual demands. However, in certain months, the supplies were not available to the fullest extent to meet all the demands in those months. The needs were in the range of 0 ac-ft per year in 2020 to 2,813 ac-ft per year in 2070. These shortages were small enough in magnitude and can be addressed by making required operational and supply availability modifications.

Figures 12a and *12b* present the results of the needs analysis for the expected conditions scenario and the two demands scenarios evaluated in the Highlands system. Due to the increased volume of supply available in the expected conditions supply scenario, the minor needs manifested in the base scenario were further diminished to approximately 45 ac-ft per year for decades 2040 and 2070. While it is not prudent to make long-term planning decisions on the basis of the expected conditions scenario, it helps to understand the impact of positive increases in supply volumes on the overall Highlands system needs.

Figures 13a & *13b* present the results of the needs analysis for the drought contingency operational scenario and the two demand scenarios evaluated in the Highlands system. It was noted that the reduction in demand due to drought triggers has a small positive impact on the needs but it was not as significant as the magnitude reduction seen in the expected conditions scenario. The needs range from 0 ac-ft per year (2020) to 69 ac-ft per year (2070). Most of SJRA's demands in the Highlands system originate from industrial and manufacturing customers. Therefore, the reduction in demands due to drought contingency operations does not significantly impact needs.

The variability of the needs on the monthly basis was analyzed for the Highlands system and summarized in *Figures 14 – 16*. It was noted that the monthly needs vary more significantly compared to the average annual shortages discussed above. A general observation is that not all decades had monthly needs or shortages so only the decades with shortages were included in the *Figures*. The detailed monthly needs serve as a better guide for planning for additional supplies in the Highlands system. In conclusion, it is recommended that SJRA adopt the needs determined for the decadal base scenario for long-term planning purposes.

The summary of the needs based on the decadal base, expected conditions, and drought contingency supply scenarios and the worst case demand scenario for the Highlands system were included in *Figure 17*. The needs presented in *Figure 17* will be used for strategy evaluation in SJRA's raw water master plan. *Tables 13-15* include the summary of the results from the needs analysis for the Highlands system.

The needs analysis focused on determining the future water needs in the SJRA's Montgomery County and Highlands system for the worst case conditions. The worst-case conditions were represented by the maximum demand projections and minimum supply availability (decadal base scenario). Additional demand projections and supply availability scenarios were considered to frame the context and variability in supplies and demands but the needs estimated for these additional scenarios were not considered for long-term planning. *Table 16* includes a summary of the future needs for SJRA's Montgomery County and Highlands system. In later phases of the study, detailed strategy evaluation will be conducted to meet these needs.

Table 10 – Summary of Montgomery County Needs (Decadal Base Scenario)

Base	SUPPLIES			DEMANDS			NEEDS		
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
2020	79,300	79,300	79,300	76,069	73,401	76,069	0	0	0
2040	77,795	72,067	77,795	127,882	112,634	97,320	50,087	40,567	19,525
2070	75,500	75,500	75,500	254,613	225,577	135,867	179,113	150,077	60,367

Table 11 – Summary of Montgomery County Needs (Expected Conditions Scenario)

Expected Conditions	SUPPLIES			DEMANDS			NEEDS		
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
2020	86,002	86,002	86,002	76,069	73,401	76,069	0	0	0
2040	75,793	75,793	75,793	127,882	112,634	97,320	52,089	36,841	21,527
2070	83,998	83,998	83,998	254,613	225,577	135,867	170,615	141,579	51,869

Table 12 – Summary of Montgomery County Needs (Drought Contingency Scenario)

Drought Contingency Mode	SUPPLIES			DEMANDS			NEEDS		
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
2020	79,300	79,300	79,300	66,167	63,899	66,167	4,354	4,254	4,354
2040	77,795	77,795	75,793	110,163	97,242	97,320	32,368	19,451	21,527
2070	75,500	75,500	75,500	216,992	192,584	116,527	141,492	117,084	41,027

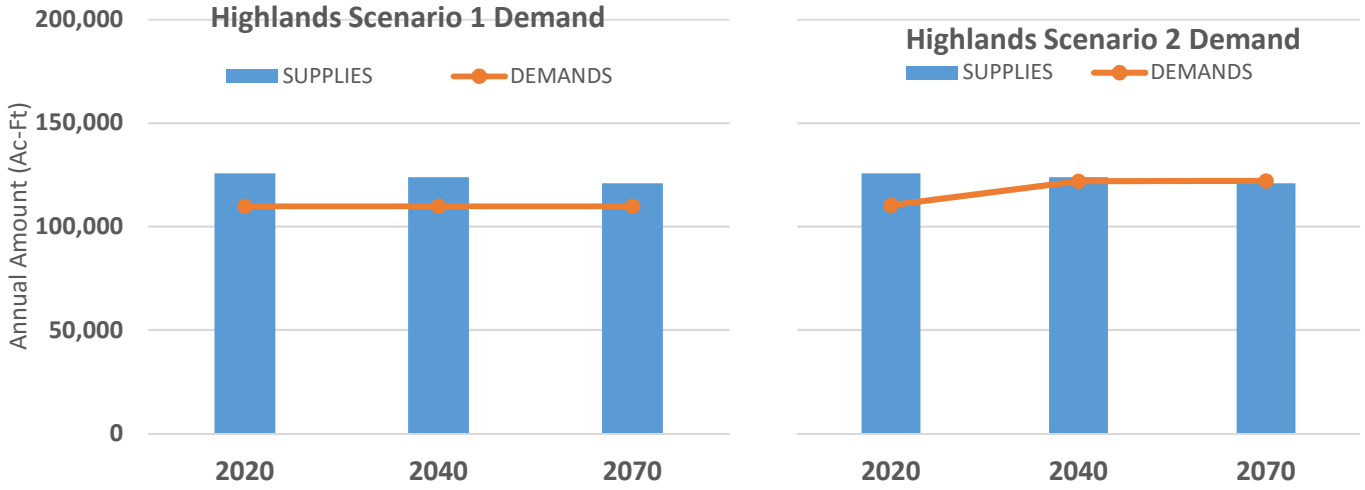


Figure 11a & 11b – Needs/Shortages summary for Highlands System for decadal base supply scenario and two demand patterns

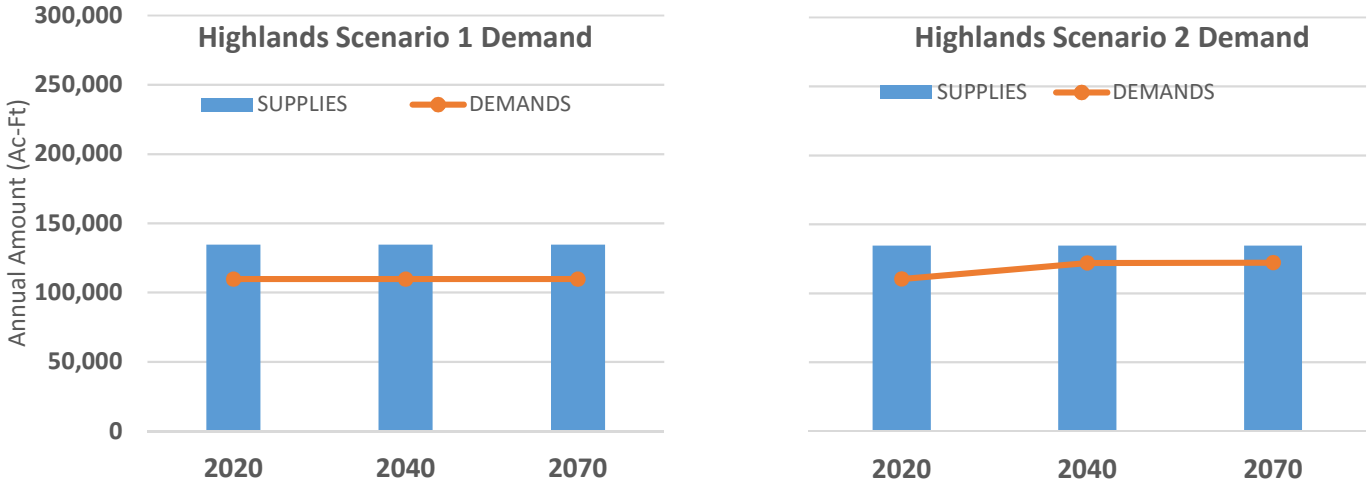


Figure 12a & 12b – Needs/Shortages summary for Highlands System for expected conditions scenario and two demand patterns

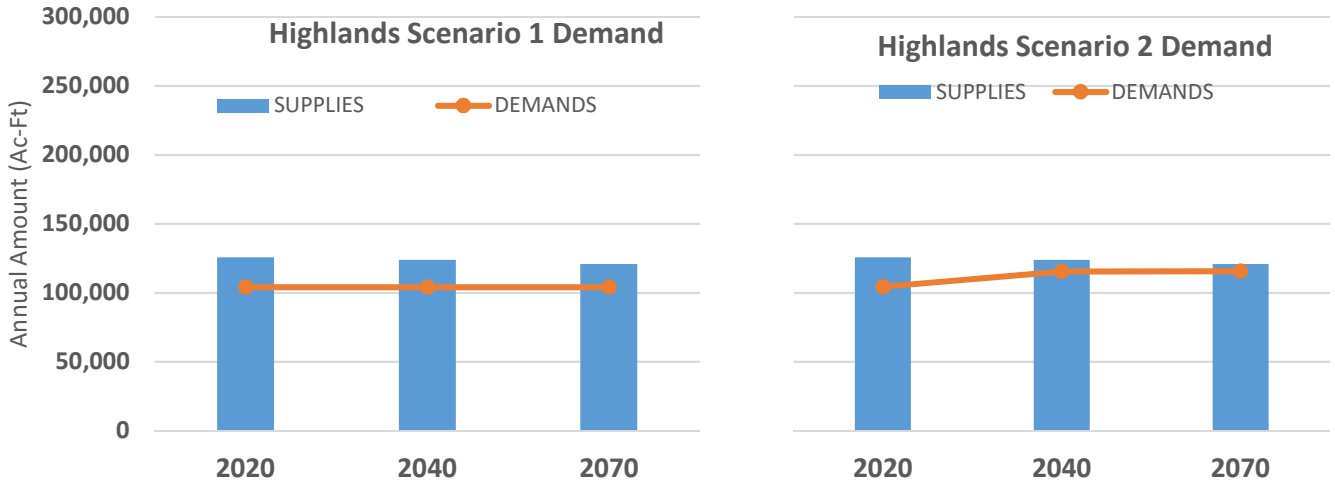


Figure 13a & 13b – Needs/Shortages summary for Highlands System for drought contingency scenario and two demand patterns

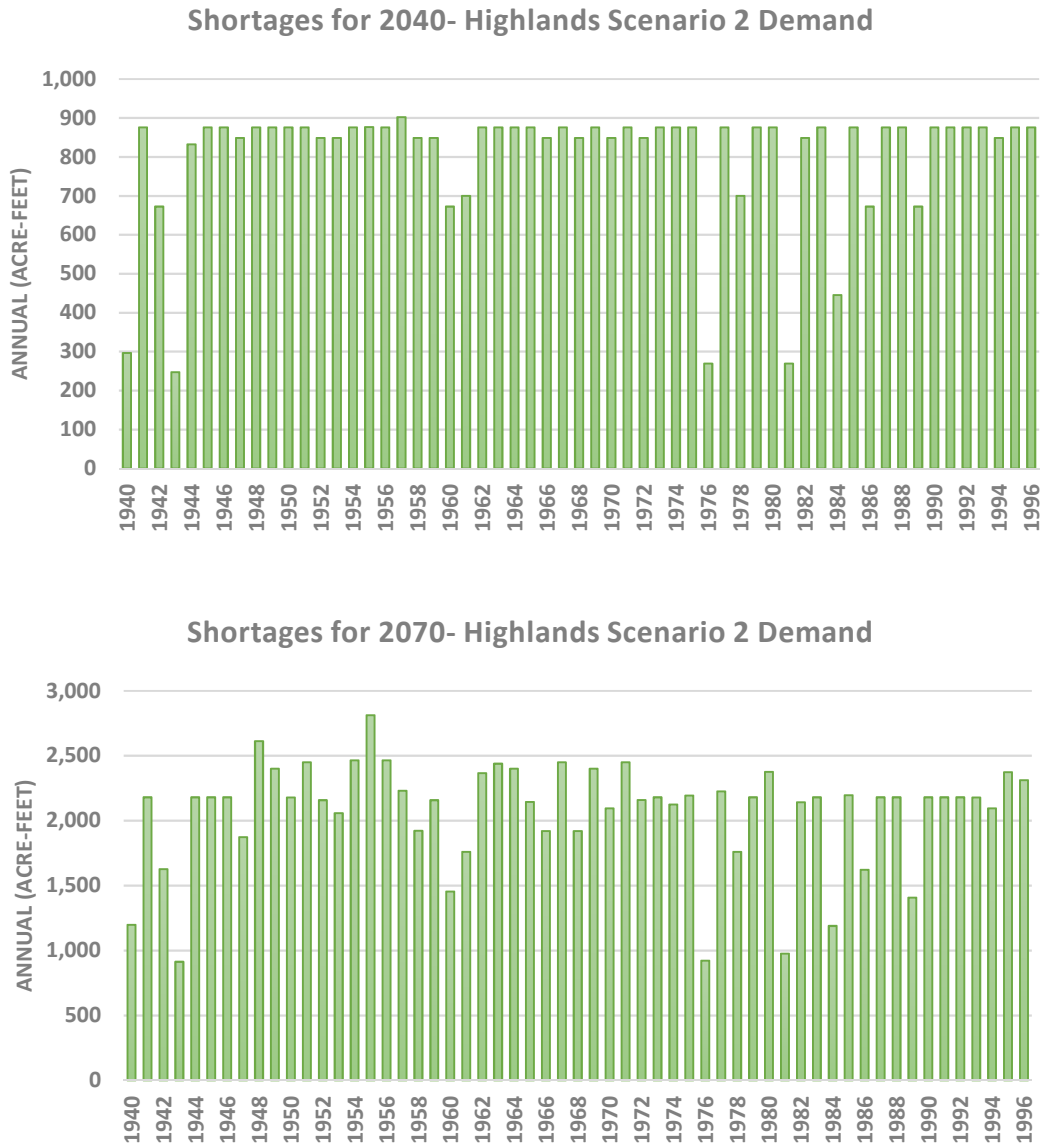
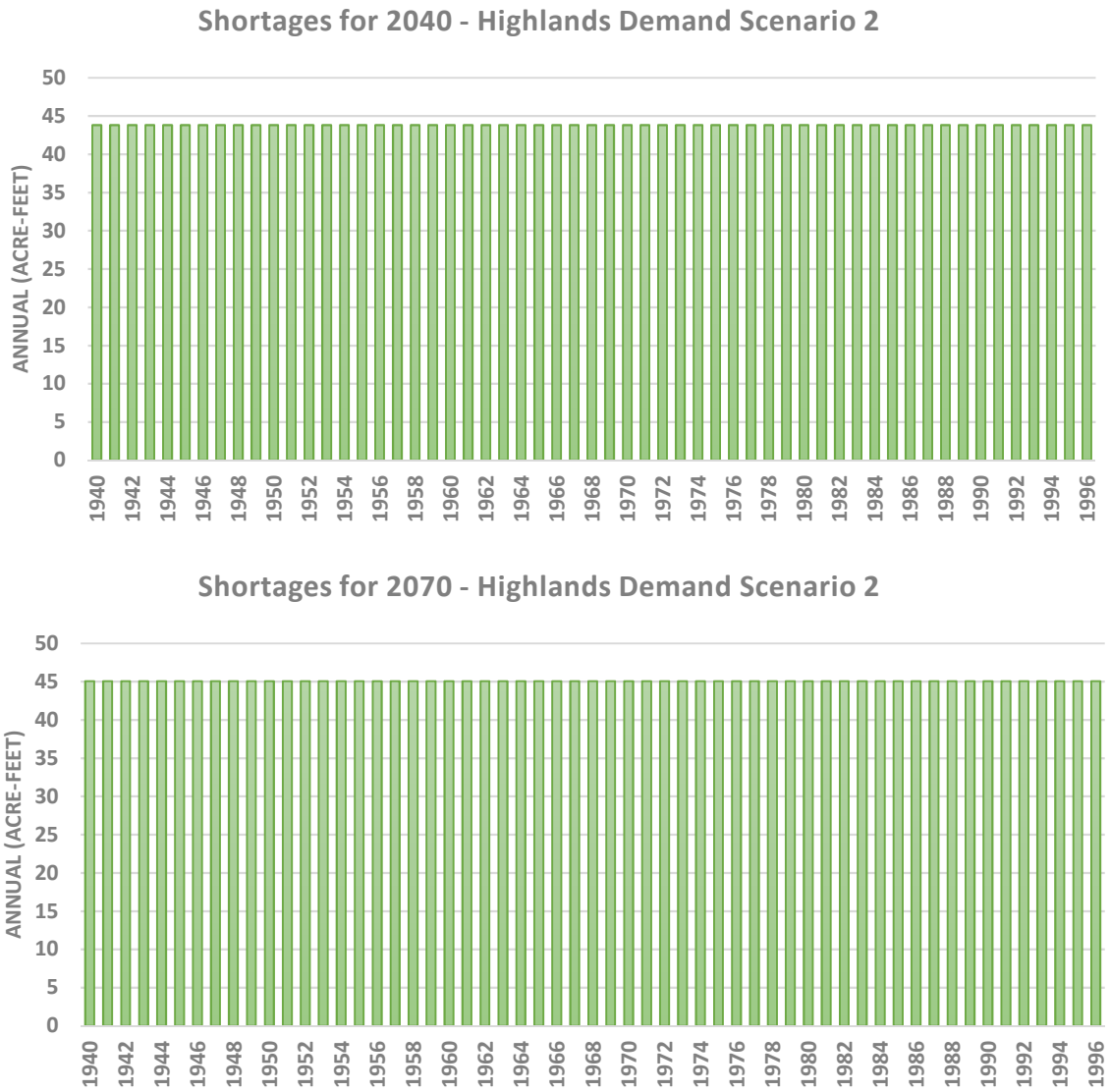


Figure 14a and 14b – Summary of monthly needs/shortages in Highlands System for decadal base supply scenario and demand scenario 2 (Plot for 2020 not included as there were no shortages)



Figures 15a and 15b – Summary of monthly needs/shortages in Highlands System for expected conditions supply scenario and demand scenario 2 (Plot for 2020 not included as there were no shortages)

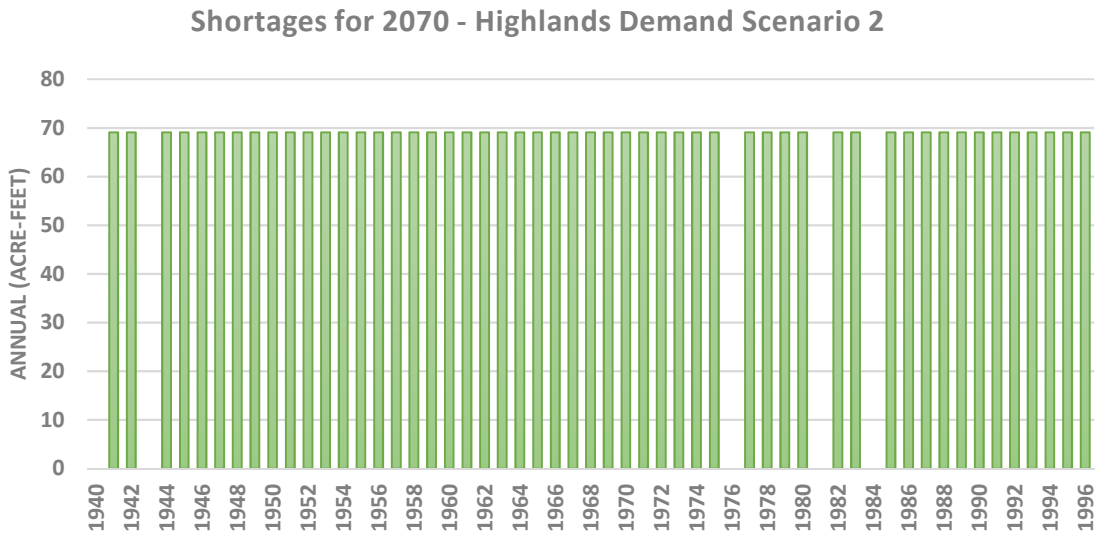


Figure 16 – Summary of monthly needs/shortages in Highlands System for drought contingency scenario and demand scenario 2 (Plots for 2020 and 2040 not included as there were no shortages)

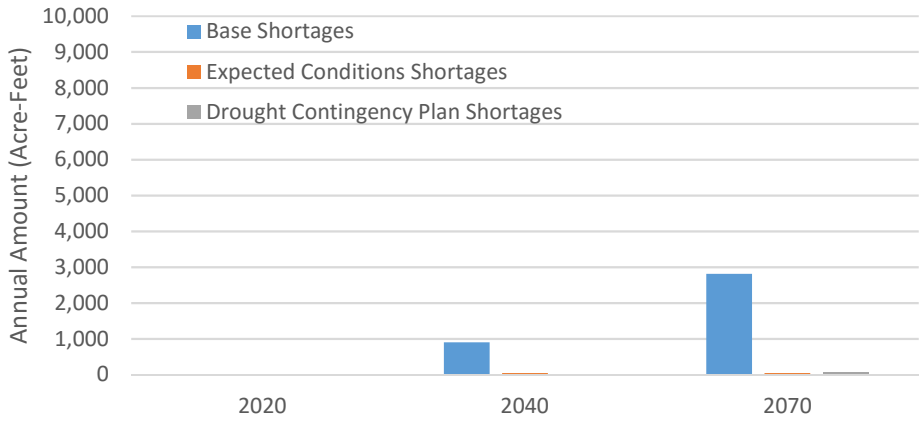


Figure 17 – Summary of overall needs/shortages in SJRA's Highlands System for Scenario 2 Demand Pattern (No shortages identified for Scenario 1)

Table 13 - Summary of Highlands System Needs (Decadal Base Supply Scenario)

Decadal Base	SUPPLIES		DEMANDS		NEEDS	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2
2020	125,646	125,646	109,827	110,319	0	0
2040	123,849	123,849	109,827	121,990	0	903
2070	120,849	120,849	109,827	122,122	0	2,813

Table 14 - Summary of Highlands System Needs (Expected Conditions Supply Scenario)

Expected Conditions	SUPPLIES		DEMANDS		NEEDS	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2
2020	134,445	134,445	109,827	110,319	0	0
2040	134,445	134,445	109,827	121,990	0	44
2070	134,445	134,445	109,827	122,122	0	45

Table 15 - Summary of Highlands System Needs (Drought Contingency Scenario)

Drought Contingency Mode	SUPPLIES		DEMANDS		NEEDS	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2
2020	125,646	125,646	103,977	104,394	0	0
2040	123,849	123,849	103,977	115,468	0	0
2070	120,849	120,849	103,977	115,582	0	69

Table 16 - Summary of Needs Considered for Long-Term Strategy Evaluation for SJRA's Montgomery County and Highlands Systems

Decadal Base Supply Scenario	Needs		
	Decade	Montgomery County System	Highlands System
	2020	0	0
	2040	50,087	903
	2070	179,113	2,813