3.0 EXISTING FLOOD CONDITIONS

The existing basin conditions, referred to as the "base case scenario", was considered to be the situation where no measures are taken to alter the inflow or outflow to the Quill Lakes with mitigation measures. The lakes would be left to rise and fall naturally and could eventually overtop their natural spill points should the current wet cycle continue. Each of the flood mitigation options presented in Section 4.0 of this report were evaluated using the base case as a baseline.

Allowing the Quill Lakes to rise naturally and potentially overflow to Last Mountain Lake will likely result in significant damage to the surrounding land and important infrastructure in the study area. A flooded area map for the Quill Lakes basin, which shows the extents of flooding for various lake levels, is shown on Plate 2. As the water levels rise, damages to surrounding properties will increase and critical infrastructure may be overtopped. These damages could potentially be mitigated by constructing dikes around properties and possibly further raising critical transportation routes, including Hwy 16, Hwy 6, Grid Road 640, and the CP rail line. Key elevations within the study area, including road and railway elevations and spill elevations of the lakes, are summarized in Table 1.

TABLE 1
KEY ELEVATIONS FOR THE QUILL LAKES

LAKE	DESCRIPTION	ELEVATION (m)	SOURCE
Little Quill	Highway 35 road shoulder near Little Quill Lake	522	Golder Final Report Table 1 (January 2015)
Big Quill	Existing Big Quill Lake spill elevation	521.47	Golder Final Report Table 1 (January 2015)
Big Quill	Highway 6 minimum road surface at centerline (shoulder)	520.98 (520.74)	Golder Final Report Table 1 (January 2015)
Big Quill	CP Rail bed	520.8 (estimated)	Golder Final Report Table 1 (January 2015)
Little Quill and Big Quill	Minimum elevation of Grid Road 640	519.62	LiDAR
Little Quill and Big Quill	Approximate elevation when cropland starts to flood	519	Golder Letter on Surface Area (April 13, 2015)
Little Quill	Little Quill Lake Spill Elevation (to Big Quill Lake) and Full Supply Level	518.16	Golder Final Report Table 1 (January 2015)

Note: 1 m = 3.28 ft

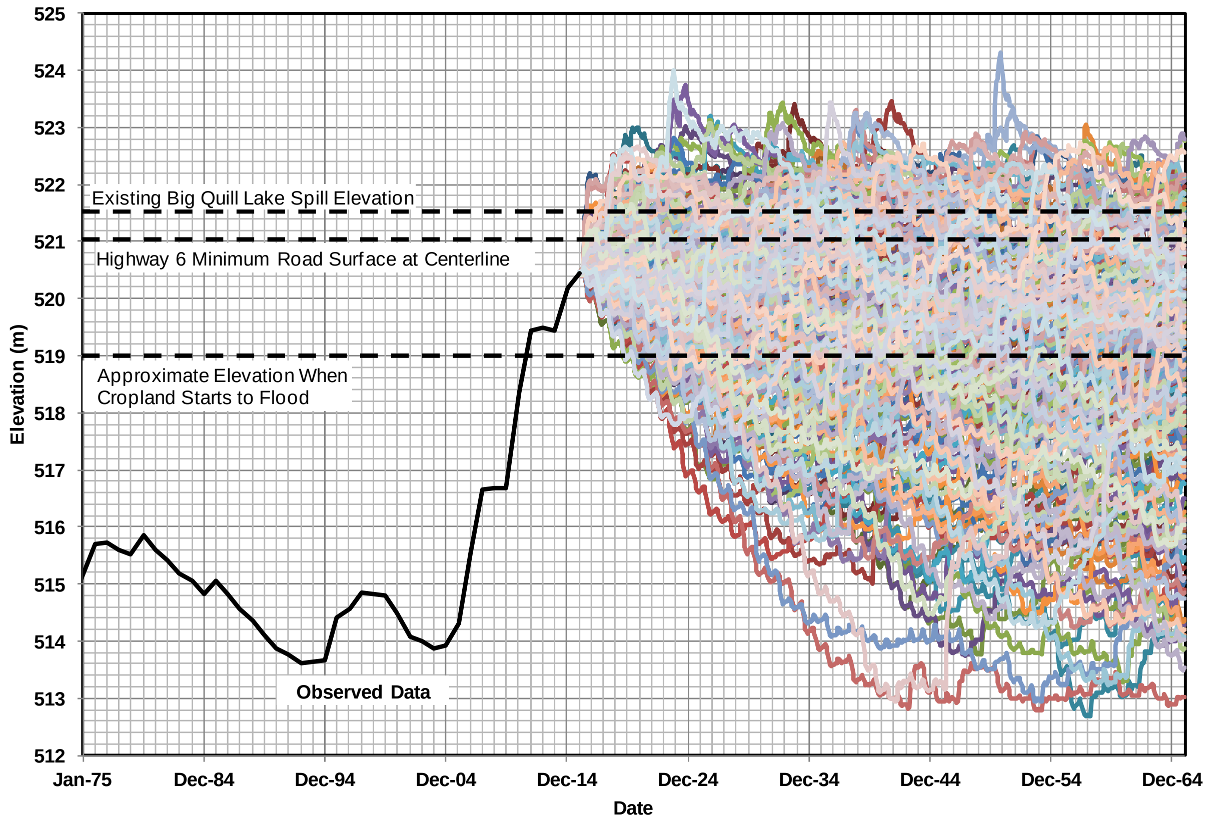
Rising water levels on the Quill Lakes could also potentially lead to significant environmental concerns within the study area. If the Big Quill Lake spill point is overtopped, the saline water from the Quill Lakes will be discharged into Last Mountain Lake, possibly causing water quality issues. Further, increased flows through Kutawagan Creek and Saline Creek could potentially cause erosion or other environmental concerns.

3.1 HYDROLOGIC ASSESSMENT OF FUTURE WATER LEVEL REGIME

The water balance model was used to simulate one thousand 50 year sequences of runoff, evaporation, and precipitation and to compute the corresponding resulting Quill Lakes water levels.

The model output consisted of one thousand water level time series, each 50 years in length. Two hundred of those one thousand water level sequences for the base case are shown in Figure 13. The water level for each simulation started at the observed 2015 water level (El. 520.45 m or 1707.51 ft) and was calculated by the model based on the various runoff, evaporation, and precipitation sequences. The computed future water levels shown in Figure 13 ranged between approximately El. 512.8 m (1682.4 ft) to El. 524.4 m (1720.5 ft). However, there are too many series shown on the graph to give an indication of trends for any one sequence.

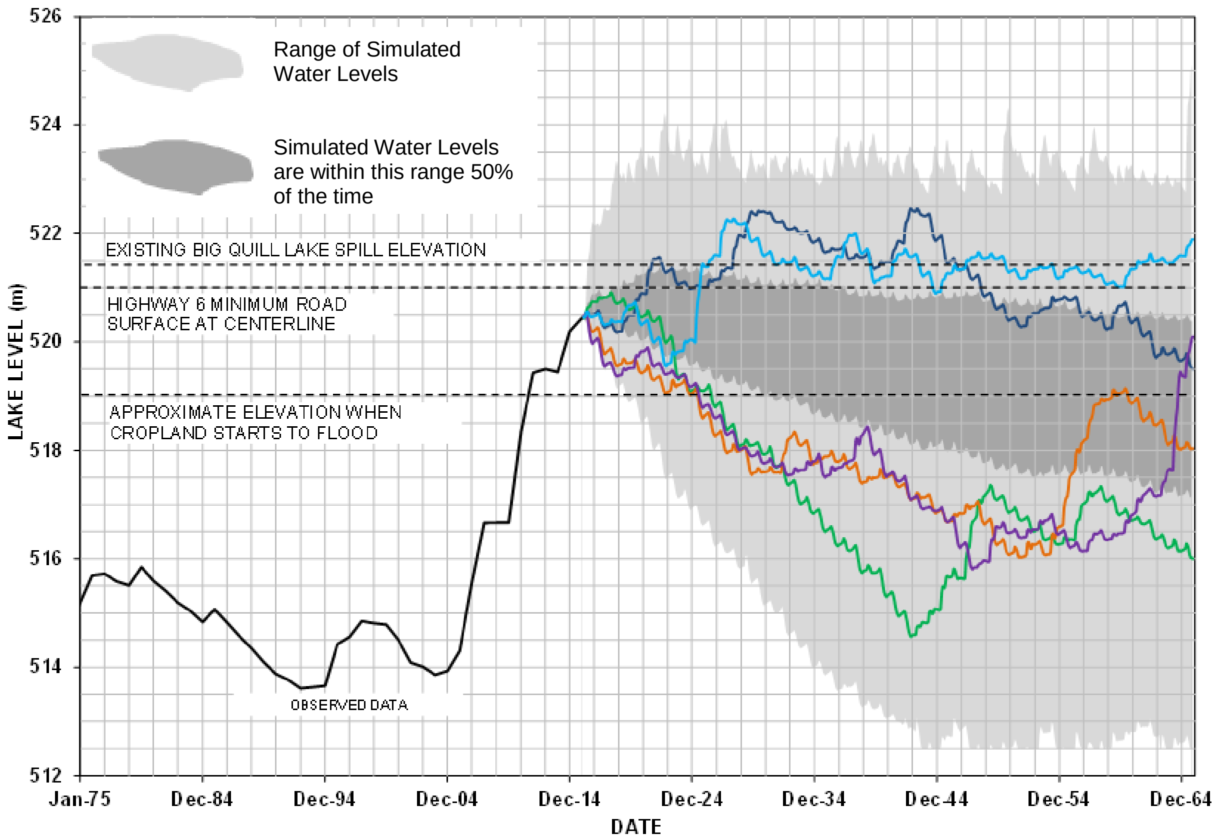
FIGURE 13
ESTIMATED BIG QUILL LAKE WATER LEVEL FOR BASE CASE (200 OF 1000 SERIES)



Note: 1 m = 3.28 ft

For clarity, 5 of the 1000 simulations shown in Figure 13 were chosen at random and are shown on Figure 14. It is evident from Figure 14 that there is significant variation between the sequences of computed water levels produced by the model. Some of the sequences show that water levels will continue to rise into the future. In some instances, the levels will stay high and exceed the spill elevation of Big Quill Lake, while in other sequences water levels could recede and return to levels close to the pre-2004 conditions.

FIGURE 14
ESTIMATED BIG QUILL LAKE WATER LEVEL FOR BASE CASE (5 OF 1000 SERIES)



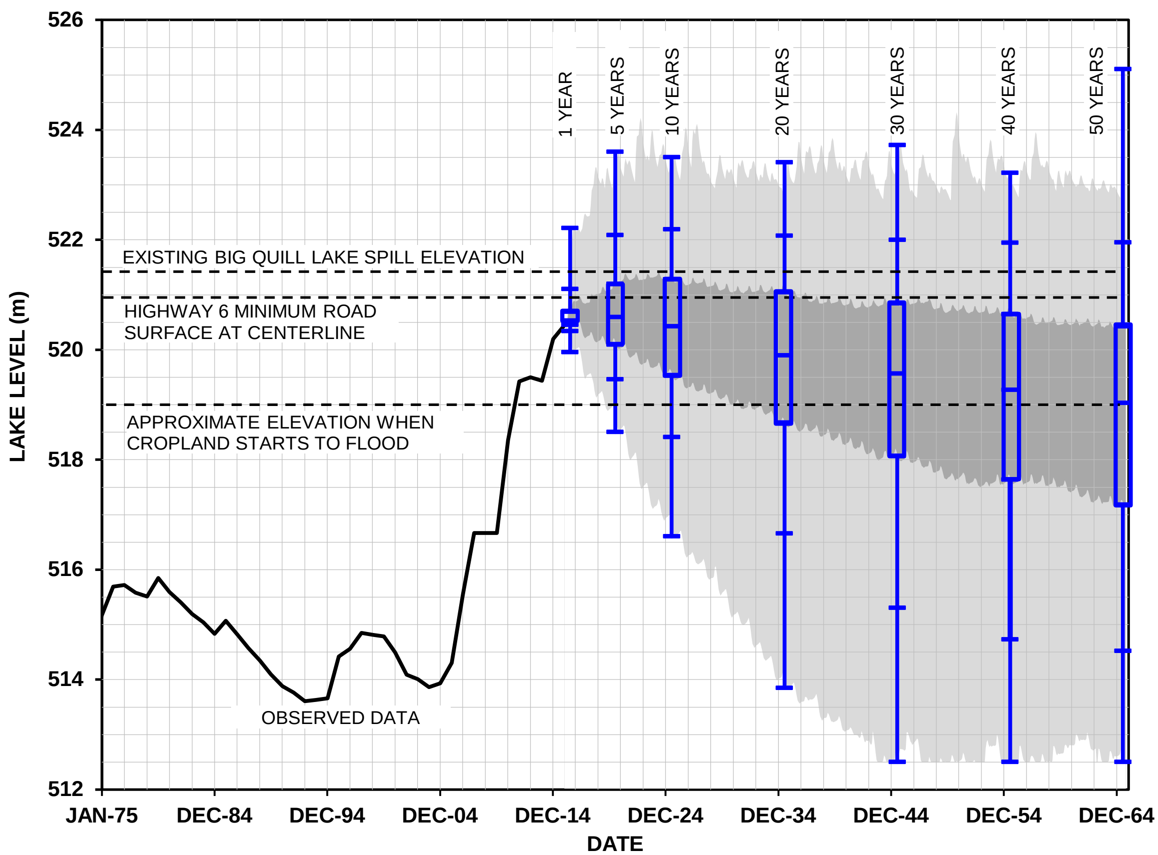
Note: 1 m = 3.28 ft

Figures 15 and 16 summarize the results of the simulated water levels on Big Quill Lake and Little Quill Lake, respectively. The grey shaded area represents the total range of simulated water levels that was estimated for the lakes, while the blue markers provide information on the simulated water levels in a given future year. More specifically, the markers show the percentage of the 1000 simulations (minimum, 5%, 25%, median, 75%, 95%, maximum) that have water levels below a particular elevation in the given year. A detailed legend for these figures is provided on Plate 6. For example, at year 10, 50% of the simulated water levels on Big Quill Lake were within the range of 519.54 m to 521.28 m with the median water being 520.43 m. The minimum and maximum water levels were 516.61 m and 523.51 m, respectively.

The trends in the data for both Big Quill Lake and Little Quill Lake were similar. On average, the analysis showed that water levels will recede slowly over the next 50 years. However, there is a low likelihood (approximately 5% of the simulations) when considering the 1000 sequences that levels will recede to pre-2004 levels.

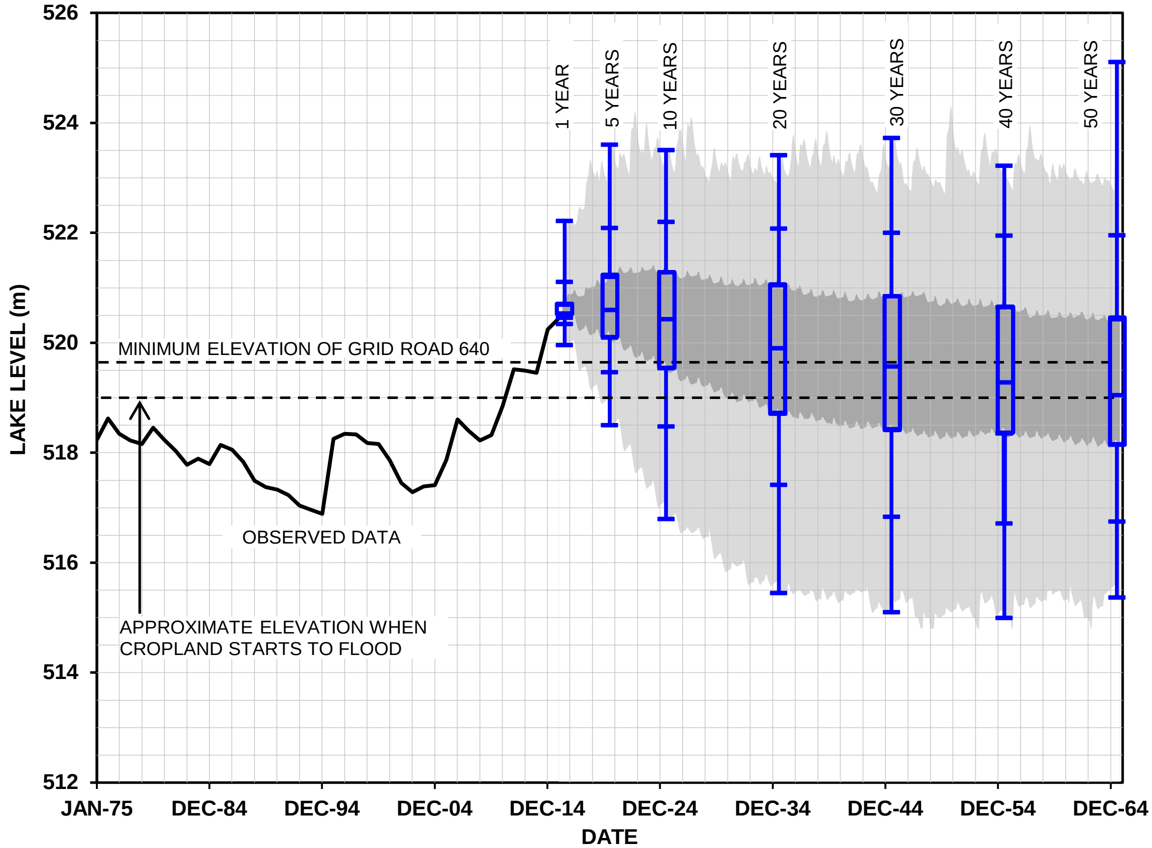
The analysis also showed that approximately a 25% of the simulations result in water levels that are near or exceed the spill elevation of Big Quill Lake after 10 years. Furthermore, the analysis showed that after 10 years, approximately 35% of the simulations result water levels that overtop the minimum Highway 6 elevation and that crop land is flooded in approximately 85% of the simulations.

FIGURE 15
STATISTICS OF SIMULATED WATER LEVEL ON BIG QUILL LAKE (BASE CASE)



Note: 1 m = 3.28 ft

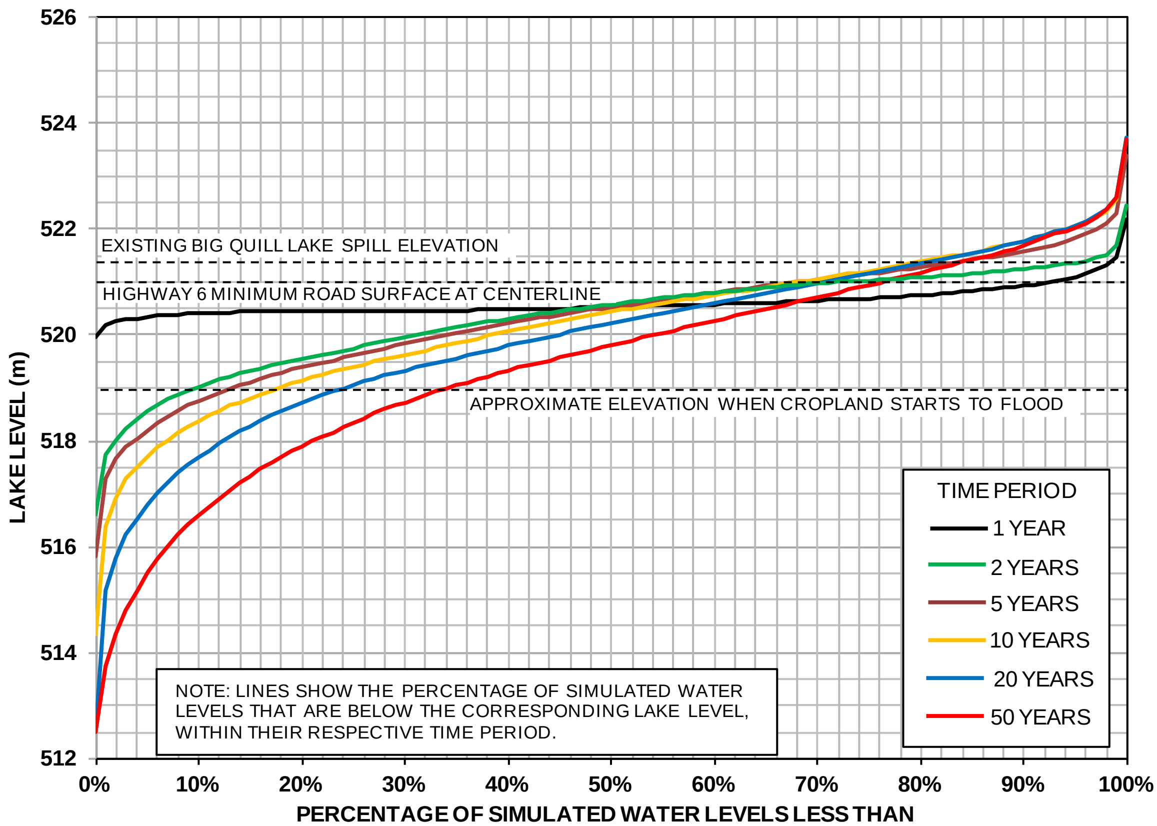
FIGURE 16
STATISTICS OF SIMULATED WATER LEVEL ON LITTLE QUILL LAKE (BASE CASE)



Note: 1 m = 3.28 ft

A duration analysis was completed on the computed lake levels for Big Quill Lake and is shown in Figure 17. These curves were generated by computing the percentage of simulated water levels that fall below the corresponding lake elevation within their respective time period.

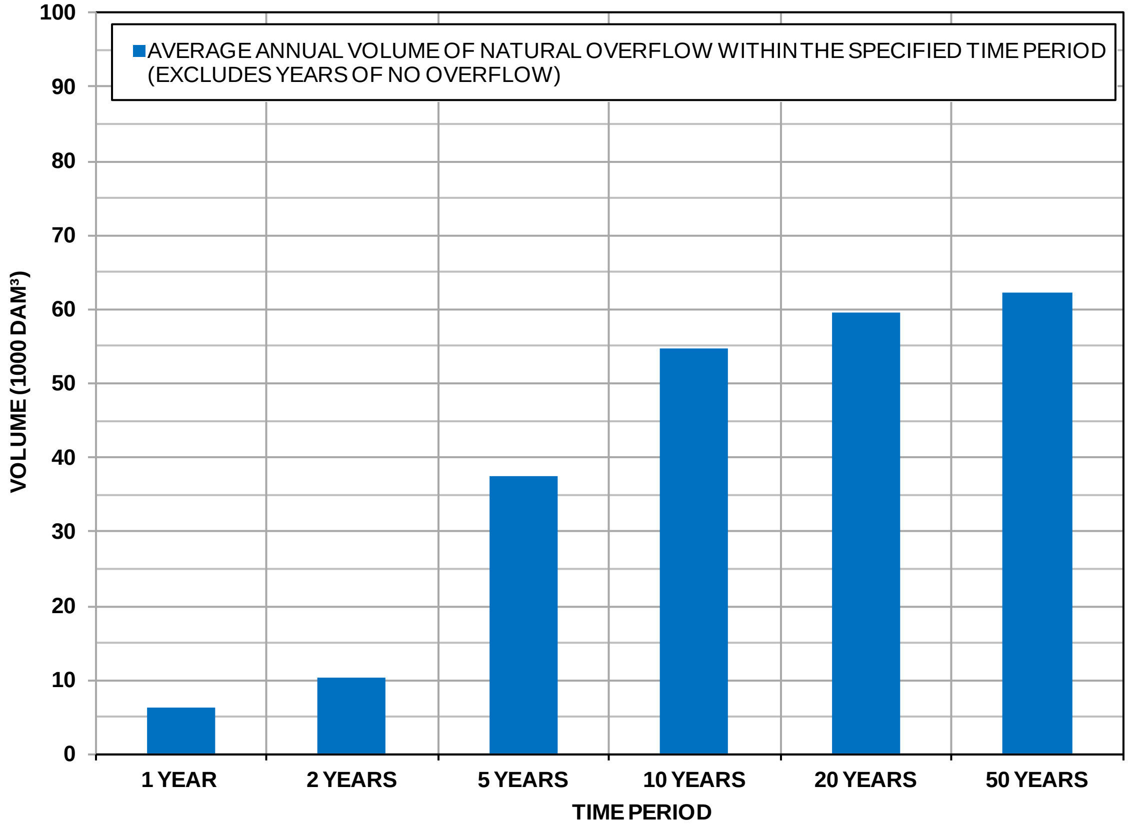
FIGURE 17
WATER LEVEL DURATION CURVES FOR BIG QUILL LAKE (BASE CASE)



Note: 1 m = 3.28 ft

The average annual volume of natural overflow from Big Quill Lake to Last Mountain Lake within a specified time was also computed and is shown on Figure 18. The average was computed excluding years of no-overflow. This was done to provide a better understand what volume should be expected in Last Mountain Lake when Big Quill Lake does overflow. For example, the average annual volume of natural overflow within the next two years (Figure 18) is approximately 10,000 dam^3. From Figure 17, 96% of the simulated water levels within the next two years are below the spill elevation, and therefore, the volume of 10,000 dam^3 is based on 4% of the simulations.

FIGURE 18
SIMULATED AVERAGE ANNUAL NATURAL OVERFLOW (BASE CASE)



Note: 1 dam^3 = 0.81 ac-ft

The results of the analysis can be synthesized in any number of ways. To provide a summary of the results relative to key future considerations, yet not create too many model result comparisons that would be unmanageable and difficult to compare to one another, we have summarized a limited number of metrics to describe the model results. Table 2 provides a summary of these metrics for the base case condition. The specifics of each of the metrics, as well as observation of the potential future water levels regime are described below. These metrics are also used to quantify the results of the model analyses of each flood mitigation alternative described in Section 5.0.

Average Water Levels

Average water levels were used to quantify how the simulated water levels compare to the starting elevation (2015 lake level) of El. 520.45 m (1707.51 ft), as well as key elevations within the basin. Typically 50 year averages were used to assess and compare long term model results, as this is consistent with the typical economic life of a flood mitigation project.

For the base case, the average water in the first year was calculated to be 520.60 m (1708.01 ft). The averages did not fluctuate notably within the first 10 years, but decreased to 519.59 m (1704.69 ft) within 50 years.

Percentage of Simulated Water Levels

Percentage of simulated water levels was used to describe the likelihood of the Quill Lakes water level rising or receding to a particular elevation at any given time and include:

- **Percentage of Simulated Water Levels not Exceeding Point of Natural Overflow –** The percentage of simulated water levels that do not exceed El. 521.47 m (1710.86 ft) and result in spill from Big Quill Lake to Saline Creek and Last Mountain Lake at any point within the specified number of years. Model results for the base case indicate that within the next year more than 99% of the simulated water levels will not overtop the spill point. This decreases to 82% within the next 10 years.

- **Percentage of Simulated Water Levels not Overtopping Hwy 6 –** The percentage of simulated water levels that do not exceed El. 520.98 m (1709.3 ft) and overtop Hwy 6 at any point within the specified number of years. Model results for the base case indicate that within the next year 92% of the simulated water levels will not overtop Hwy 6. This decreases to 67% within the next 10 years.

- **Percentage of Simulated Water Levels not Exceeding Minimum Cropland Elevation –** The percentage of simulated water levels that recede below El. 519 m (1702.8 ft) at any point within the specified number of years. This is a significant elevation because no flooding of farmland will occur below El. 519 m (1702.8 ft). Model results for the base case indicate that within the next five years less than a 1% of the simulated water levels are below El. 519 m (1702.8 ft). This increases to 18% if the next 10 years are considered. The model also indicated that at anytime within the next 50 years 34% of the simulated water levels are below El. 519 m (1702.8 ft).

- **Percentage of Simulated Water Levels not Exceeding December 2015 Level –** The percentage of simulated water levels that are lower than the current water level of El. 520.45 m (1707.51 ft) at any point within the specified number of years. The percentage of water levels not exceeding El. 520.45 m within the next year is 22%. This increases to 50% within the next 10 years and 64% within the next 50 years.

TABLE 2
SUMMARY OF MODEL RESULTS FOR BASE CASE– BIG QUILL LAKE

METRIC	1 YEAR	2 YEARS	5 YEARS	10 YEARS	20 YEARS	50 YEARS
Average water level of Big Quill Lake (m)	520.60	520.62	520.64	520.58	520.29	519.59
Average water level of Little Quill Lake (m)	520.60	520.62	520.64	520.58	520.32	519.82
Percentage of simulated water levels not exceeding point of natural overflow from Big Quill Lake to Last Mountain Lake (El. 521.47 m)	>99%	97%	87%	82%	83%	86%
Percentage of simulated water levels not overtopping Hwy 6 (El. 520.98 m)	92%	70%	67%	67%	70%	76%
Percentage of simulated water levels not exceeding minimum cropland elevation (El. 519 m)	<1%	10%	13%	18%	24%	34%
Percentage of simulated water levels not exceeding December 2015 level (El. 520.45 m)	22%	45%	47%	50%	56%	64%

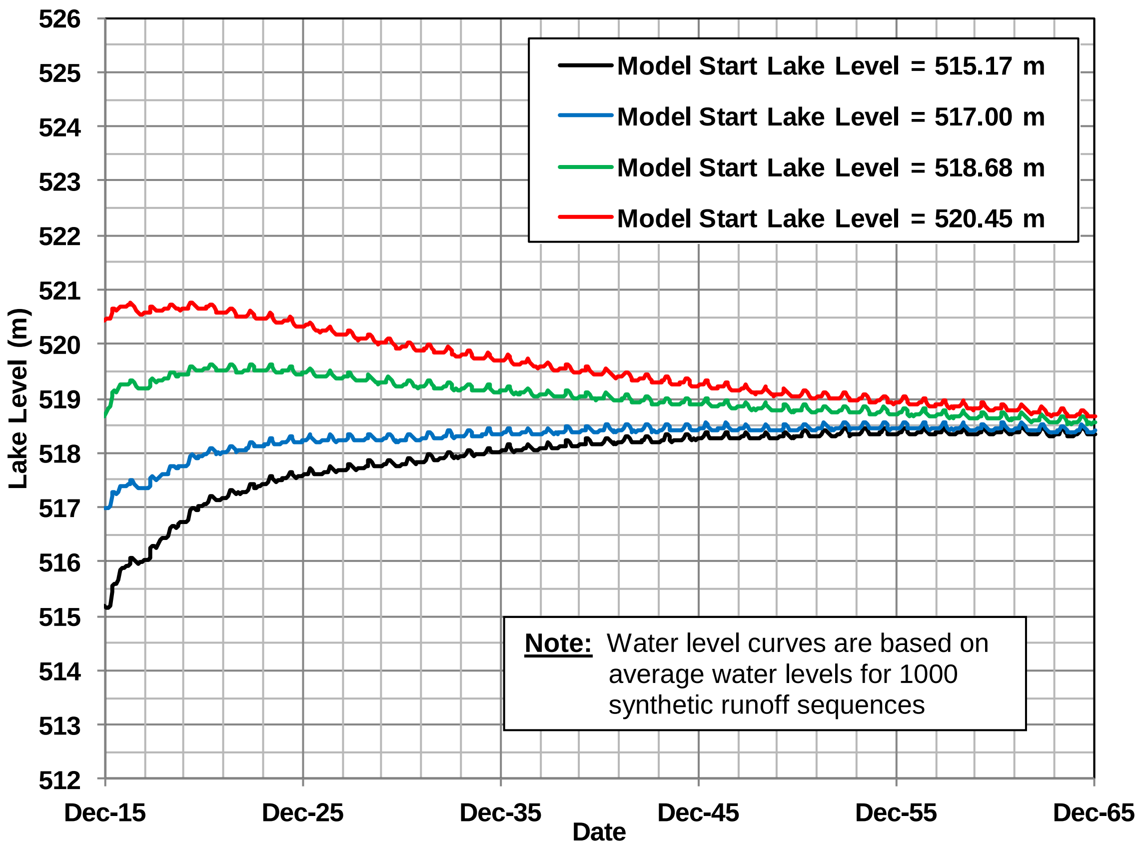
Note: 1 m = 3.28 ft

3.2 SENSITIVITY ANALYSIS OF STARTING LAKE LEVEL

The runoff sequences developed by the SAMS Autoregressive program were used to determine future water levels on Quill Lake as described above. The starting water level on Quill Lake used for the simulation of future water levels is 520.45 m, which corresponds to the water level on December 31, 2015. A sensitivity analysis was conducted to determine the effects of using different starting water levels on the future water levels. A range of starting levels between 520.45 m to 515.17 m was used in the analysis and the resulting average water levels are shown on Figure 19.

Figure 19 shows that altering the starting water level had the most significant impact within the first 20 years. After approximately 40 years, the computed average water levels for all starting water levels converge to within approximately 0.75 m (2.5 ft). After 50 years, the difference between the average water levels is within approximately 0.5 m (1.6 ft). Therefore, average water levels for the full 50 years were typically used when presenting and comparing model results. Furthermore, 50 years is consistent with the typical economic life of a flood mitigation project.

FIGURE 19
SENSITIVITY ANALYSIS OF STARTING LAKE LEVELS



Note: 1 m = 3.28 ft