1 Street Light Management System

Category	Subcategory	Grade
Overall Grade		D
Physical Health		
	Overall Condition	C
	Risk-Based Condition	A
Financial Health		
	Catch Up	F
	Keep Up	F

1.1 Background

1.1.1 What Services Do These Assets Provide?

The Street Light Management System is comprised of street lighting throughout Livermore. Street lights improve the visibility of and for pedestrians, assist drivers navigating at night, and deter theft by illuminating neighborhood streets. In addition, decorative street lights elevate the overall aesthetic of the City.

1.1.2 *Who is Responsible?*

The City of Livermore currently owns, operates, and maintains approximately 8,000 street lights. In the case where a street light is located on a utility pole, the City is responsible for the street light fixture but not the utility pole. The City is not responsible for street lights that are located on Caltrans (ex: State Route 84) or private roadways.

1.2 Asset Register

1.2.1 Asset Definition

An asset in the Street Light Management System is defined as something with value that is owned and managed by the City. For City staff use, an asset is defined at the level in which a maintenance work order will be generated. In the case of street lights, each light fixture and each pole is considered a separate asset.

Some examples of the street lights are shown in the following images. For street lights located on utility poles, as in the image on the right, the City is only responsible for the replacement of the street light fixture; the replacement of the pole is the responsibility of the utility company. For street lights located on traffic signal poles, the street light fixture is included in this analysis; the pole is included in the Traffic Signal Asset Management Plan.

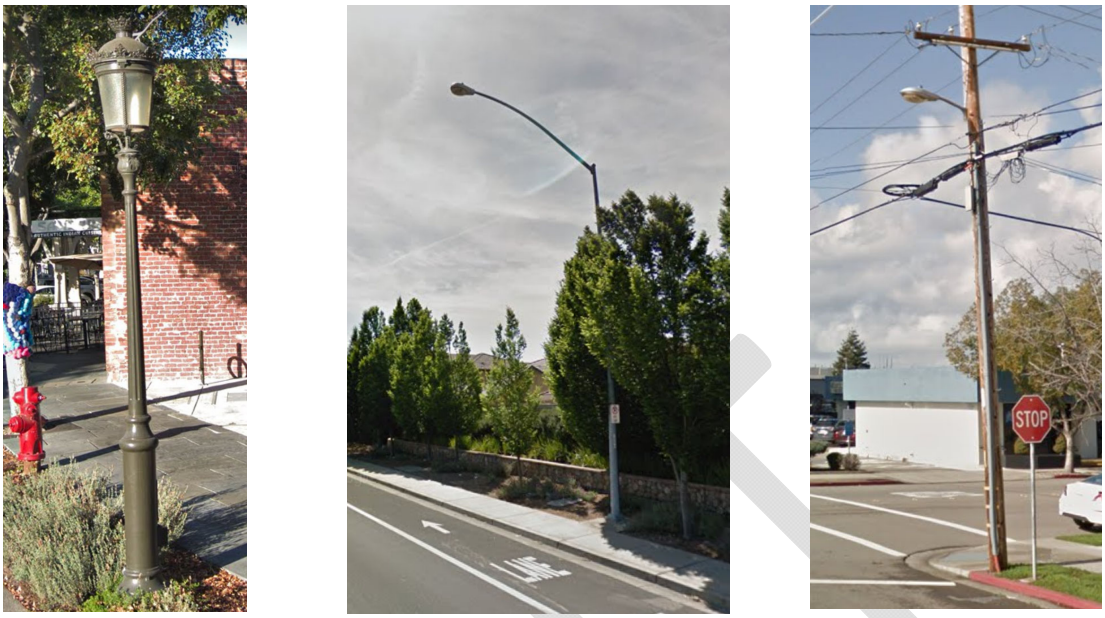

Figure 1-1 Street Light Type Examples

Figure 1-2 Traffic Signal Pole/Street Light Example

1.2.2 Asset Class

Assets are grouped into classes for modeling and management purposes. An asset class generally refers to a group of assets that behave similarly (e.g., useful life, rehabilitation activities). Grouping the assets into these classes allows easier life-cycle behavior modeling. The asset classes for the Street Light Management System are light fixtures and poles.

1.2.3 *Asset Hierarchy*

The asset hierarchy of the Street Light Management System is organized by light fixtures and poles. This hierarchy helps organize assets and supports asset management decisions by asset class. The following figure illustrates the general asset hierarchy for the street lights.

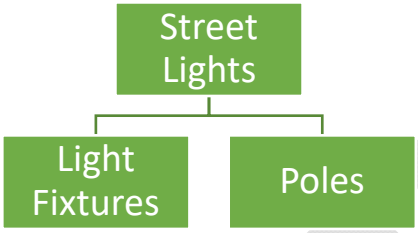

Figure 1-3 Street Light Management System Hierarchy

1.2.4 *Asset Inventory*

It is estimated that the City is responsible for approximately 8,000 street light fixtures (a fixture is the component of the entire asset which actually emits the light and is located on the end of the mast arm), based on staff knowledge and information from the City's databases (e.g., GIS, Excel lists). The City is currently locating and collecting additional street light data, including location, ID or badge number, light/lamp type and size, and pole type.

In 2013 the City replaced over 6,200 street light fixtures with LED retrofit kits. Since the retrofit project, the City has replaced approximately 1,000 of these retrofitted light fixtures with more reliable LED lights through a full LED conversion process. The estimated 1,800 remaining lights will be converted to LED in the future.

Street lights are typically located on four different pole types: ornamental, street light, traffic signal, and utility pole. As mentioned previously, the utility poles are not the City's responsibility and so are not included in the inventory and the signal light poles are included in the Traffic Signal Asset Management Plan. As such, the number of poles is lower than the number of light fixtures. The following table summarizes the estimated asset inventory. There are approximately 14,040 pole and light assets in the Street Light Management System.

Table 1-1 Asset Inventory

Asset Class	Type	Quantity
Poles		
	Street Light	4,854
	Ornamental	1,186
Light Fixtures		
	LED – Retrofitted (or converted)	6,200
	Non – LED	1,800

1.2.5 *Asset Replacement Cost*

Each asset in the asset register was assigned an estimated replacement cost. The replacement costs were assigned

based on asset class and type as shown in the following table.

Table 1-2 Asset Class Base Replacement Cost

Asset Class	Type	Base Replacement Cost
Poles		
	Street Light	$5,000
	Ornamental	$6,000
Light Fixtures		$1,000

A 30% markup was added to each asset replacement cost to help account for project costs (e.g., design, engineering, permit fees).

The sum of all replacement costs in the Street Light Management System adds up to approximately $51.2 million. The following figure presents the breakdown of this cost between light fixtures and poles.

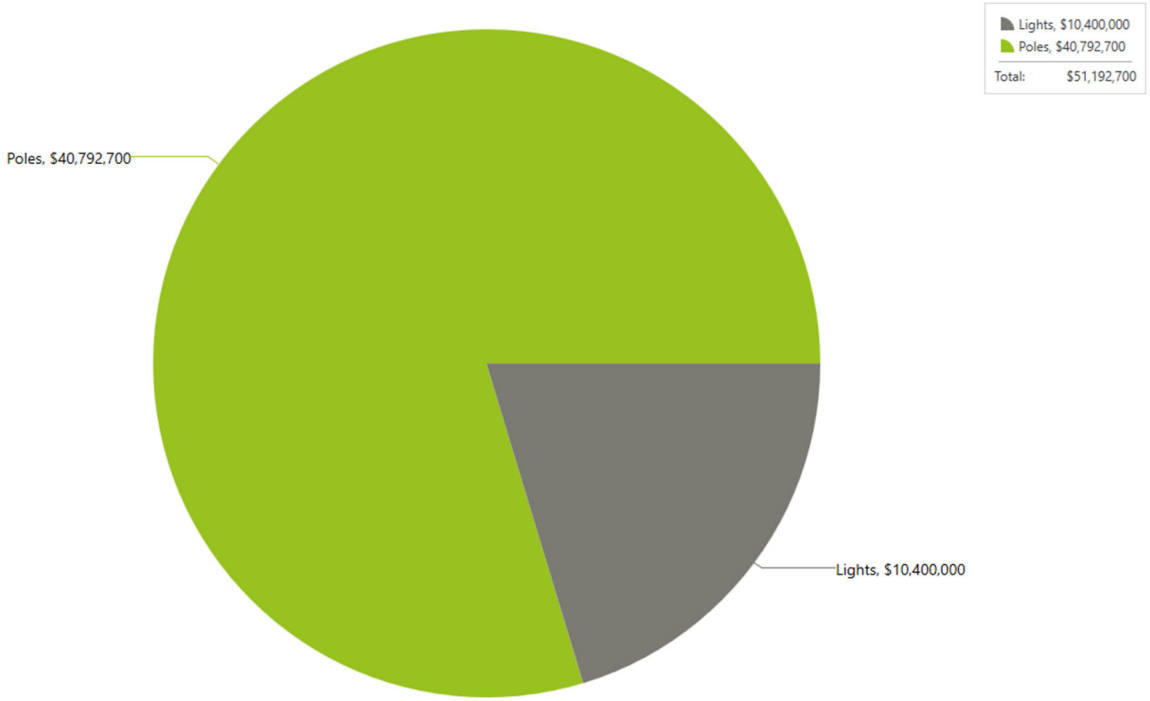

Figure 1-4 Street Lights Replacement Cost by Asset Class

1.2.6 Installation and Consumption Profile

The installation profile gives an indication of the age of the street light assets. As the City's current data did not support a full installation year analysis, installation years for most of the assets were estimated by decade based on the historical development of the City. The following table shows the estimated installation profile for the standard street light and ornamental poles.

Table 1-3 Light Pole Installation Profile

Estimated Decade of	Estimated Number of

Installation	Poles Installed
1950's	282
1960's	756
1970's	1,400
1980's	688
1990's	543
2000's	1,253
2010's	1,118

Where possible, the light installation years were based on the City's historical records. Most of the lights were upgraded to LED since 2012, so the LED lights were given an estimated install year of 2012. The remaining lights have unknown installation years; replacement needs for these lights will be covered in the following sections.

More important than the installation data is the estimated current state or consumption of the assets. Consumption represents the percentage of an asset's expected life that it has used up or consumed. As illustrated in the following figure, most street light assets have consumed approximately 70% or less of their useful lives. Although 70% may seem high, these assets may be in relatively good condition with years of life left, as explained in the next section.

The following figure shows the consumption profile represented in 2017 dollars. Approximately $1.8 million worth of assets are estimated to be fully consumed based on age. The replacement of these assets should take place in the near future.

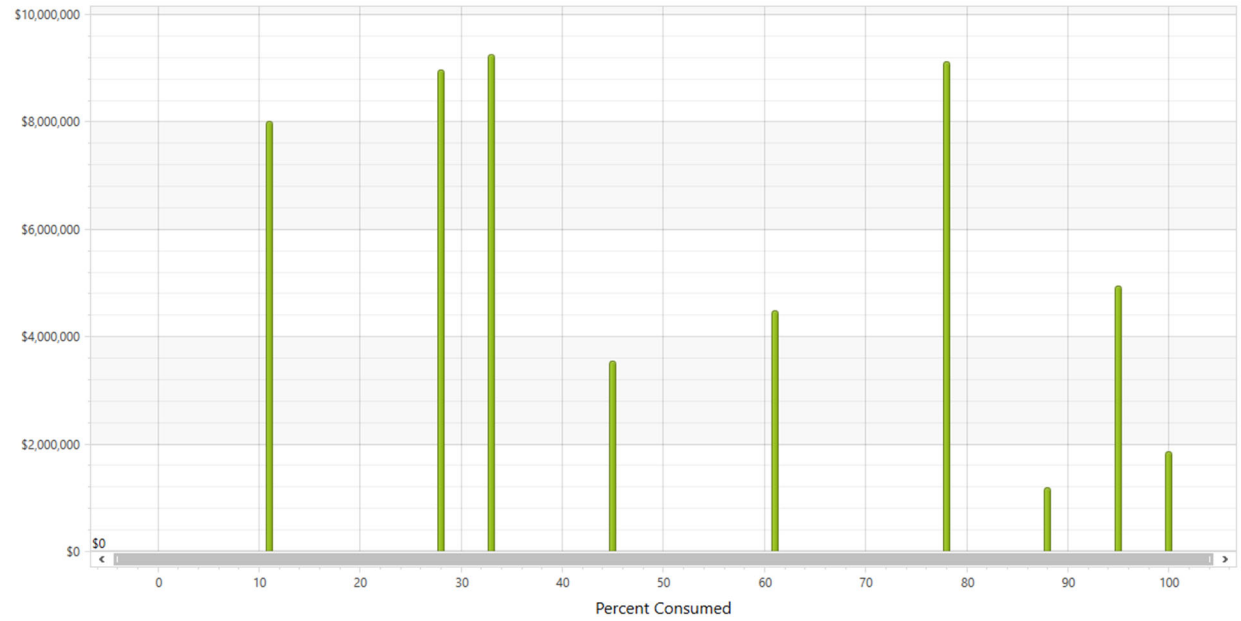

Figure 1-5 Consumption Profile

1.2.7 Condition Assessment

Condition is one of the best indicators for estimation of immediate and/or future repair and replacement work. For

the street light system, the initial condition assessment is generally based on estimated age rather than on-site visual inspection. However, if an estimated age was not available for an asset, it was assigned an estimated condition score. The condition was assessed based on the following condition scale.

Table 1-4 Condition Scale

Condition Score	Description
1	New or nearly new
2	Very good
3	Good or as expected based on age
4	Poor or recommended replacement within near-term
5	Failed or nearing failure, needs immediate attention

Light assets that were not converted to LED were considered to be condition 4 as they are recommended for LED conversion in the near future. Although these lights may be functioning, they no longer align with the City's sustainability goals and will be replaced with LEDs.

1.3 Risk Analysis

1.3.1 Probability of Failure

For most of the street light assets, Probability of Failure (PoF) was calculated based on the estimated age by comparing the estimated installation year and estimated useful life based on the City's historical usage, manufacturer's estimation, and/or other reputable resources (e.g., research results, ENR, neighboring cities). As mentioned previously, PoF for non-LED lights was calculated based on a condition score of 4. Although these lights may be functioning, they no longer align with the City's sustainability goals and will be replaced with LEDs.

PoF information for each asset is available in the City's IRIS database. This information is too lengthy to include in this report.

1.3.2 Consequence of Failure

The street light Consequence of Failure (CoF) is rated based on the function the street light serves, as well as the functional classification of the adjacent roadway. The criticality ratings for street lights are summarized in the following table.

Table 1-5 Street Light Criticality Level

Criticality Level	Location
Very High	Intersection Safety Lighting for Arterial Streets Intersection Safety Lighting for Collector Streets Enhanced Pedestrian Crosswalks on Arterials
High	Intersection Safety Lighting for Residential Streets Non-Intersection Lights on Arterial Streets Enhanced Pedestrian Crosswalks on Collectors
Medium	Non-Intersection Lights on Collector Streets Enhanced Pedestrian Crosswalks on Residential Streets

Low	Non-Intersection Lights on Residential Streets

As mentioned previously, the City is currently in the process of assessing its street lights by pole and light type. In order to estimate the CoF for the street lights, the locations of the estimated inventory were distributed based on the number of intersections and total lengths of the road classes in the City (i.e., arterial, collector, residential). As such, the resulting CoF distribution is a high-level estimate; it is recommended that the CoF be reapplied once the full asset inventory is completed. CoF information for each asset is available in the City's IRIS database. This information is too lengthy to include in this report.

1.3.3 Risk Analysis Results

The following figure shows the resulting overall risk profile for the street lights. This profile incorporates both the PoF and CoF scores to prioritize the assets. The assets in the red zone of the risk matrix are the highest risk assets that have both a high probability and high consequence of failure. Assets with a risk score of 4 or higher were considered high risk assets.

Based on the high-level inventory and risk analysis, it is estimated that $1.7 million worth of assets are in the high-risk red zone. This includes the street light poles that were estimated to be installed in the 1950's and 1960's in very high CoF areas, as well as the first priority light fixtures for the LED conversion. It is important to note that the high-risk rating is based on estimated asset inventory and estimated age only; an on-site condition assessment may result in an improved risk assessment.

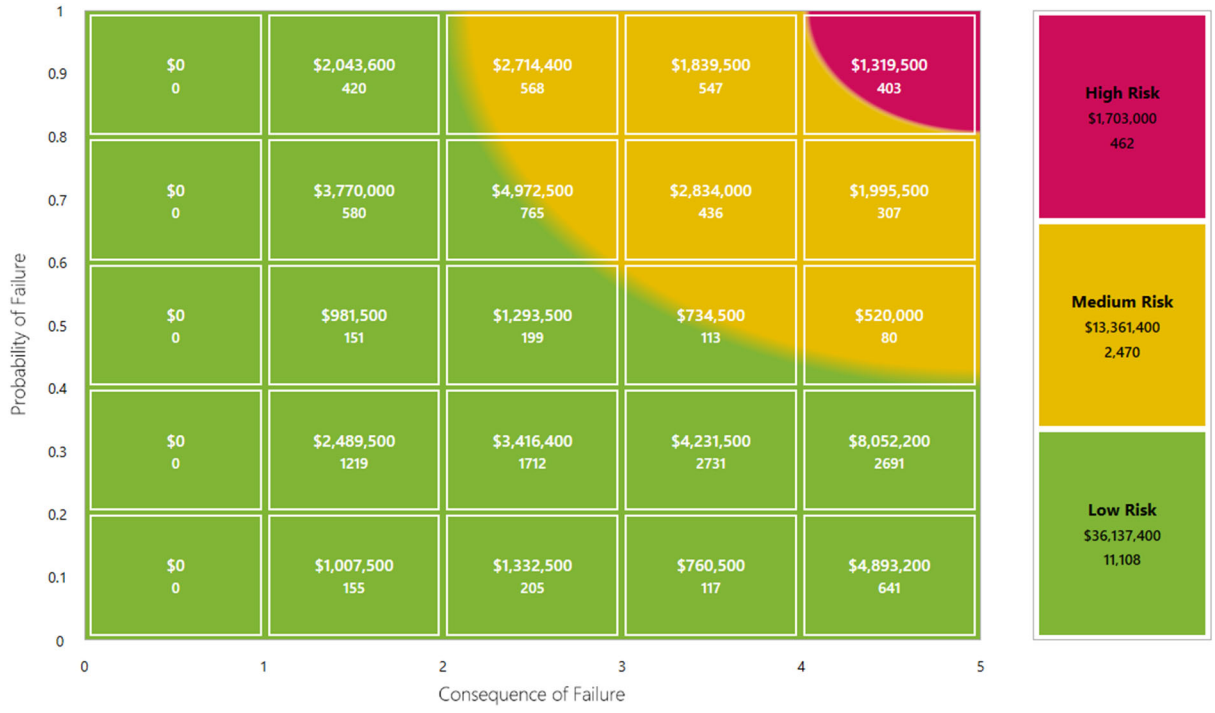

Figure 1-6 Risk Matrix

1.4 Future Needs

1.4.1 Life Cycle Cost Logic

Life cycle cost logic, also known as management strategies, were developed for the street light assets. Each asset class was assigned a management strategy that includes the rehabilitation and replacement activities to best characterize the life cycle investment needs for the asset.

Replacement is one of the major activities captured in the management strategy. The useful lives of the City's street light assets were assigned through extensive work with key members of the City's management and operations or maintenance staff. The management strategies are shown in Appendix A.

1.4.2 Long Range Replacement and Rehabilitation Profile

The following figures show the replacement and rehabilitation needs (including 30% for project delivery costs) for which the City is responsible over a 30-year span in 2017 dollars. Utilizing a deterministic model (i.e., assets fail at the end of their estimated useful lives), the average annual replacement and rehabilitation needs over the 30-year planning horizon is approximately $1.5 million.

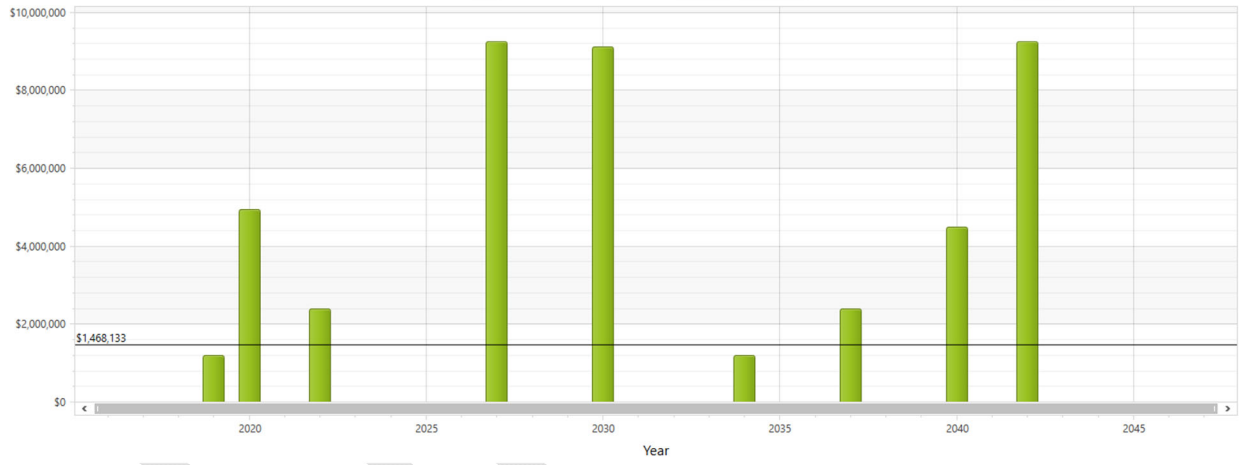

Figure 1-7 Street Light 30-Year Replacement and Rehabilitation Profile (Deterministic)

The 30-year life cycle cost analysis was repeated utilizing a probabilistic model. In this scenario, asset failures were smoothed to show that assets may fail sooner or later than their expected useful lives; as such, this scenario may present a more realistic estimate of the future asset failures and funding needs. The probabilistic analysis incorporates the concept of randomness in that early or late asset failures are distributed randomly using the assigned standard deviation (i.e., 20%). The probabilistic model predicts the annual replacement and rehabilitation needs to be approximately $1.3 million.

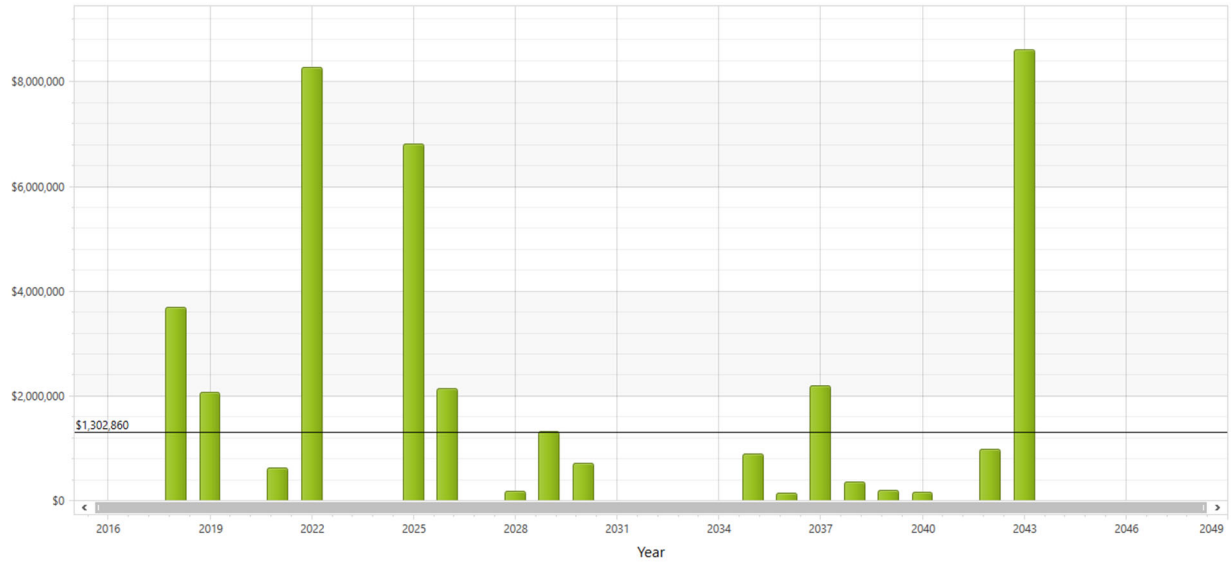

Figure 1-8 Street Light 30-Year Replacement and Rehabilitation Profile (Probabilistic)

Both analyses above represent results in 2017 dollars. Expecting the cost of construction will increase with time, a 3% annual inflation factor was utilized. With 3% inflation over the 30-year planning horizon, the projected annual investment need for the deterministic model jumped from $1.5 million per year to $2.3 million per year. Similarly, for the probabilistic model, the annual investment need increased from $1.3 million per year to $1.9 million per year. The results of these analyses are presented the figures below.

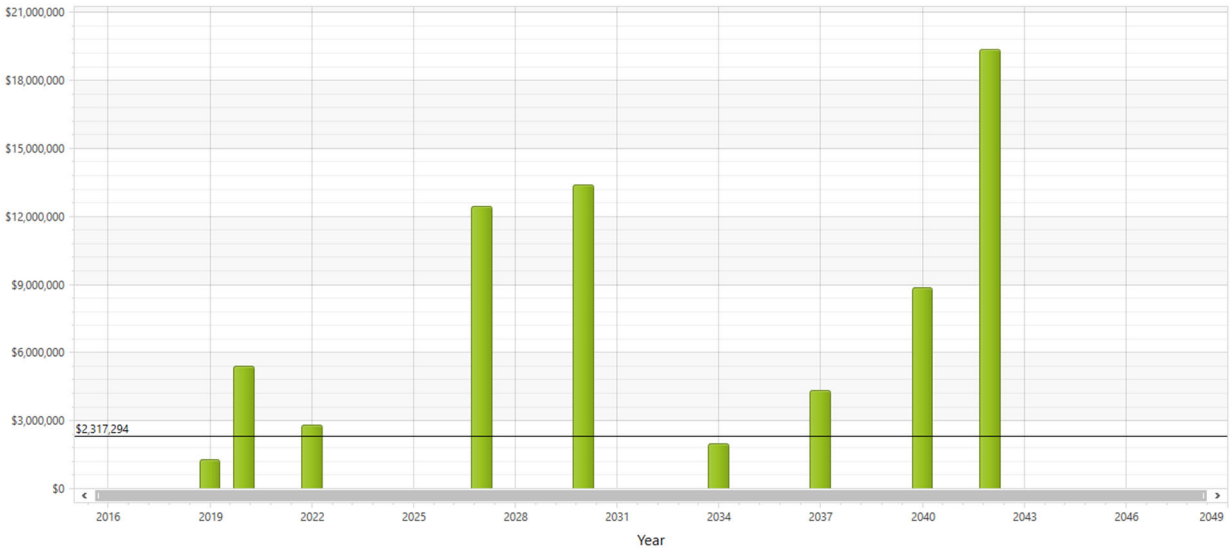

Figure 1-9 Street Light 30-Year Replacement and Rehabilitation Profile (Deterministic, 3% Inflation)

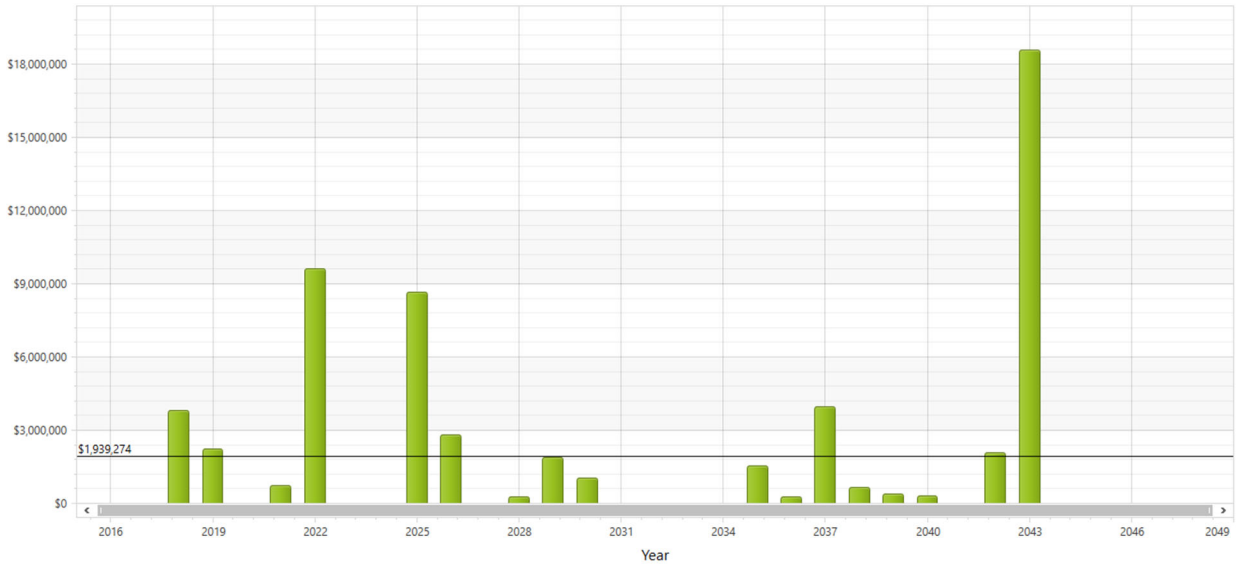

Figure 1-10 Street Light 30-Year Replacement and Rehabilitation Profile (Probabilistic, 3% Inflation)

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The following table summarizes the 30-year replacement and rehabilitation needs for the Street Light Management System.

Table 1-6 Street Light Management System 30-Year Summary

Analysis Type	R&R Average
Deterministic	$1.5 M
Probabilistic	$1.3 M
Deterministic with 3% Inflation	$2.3 M
Probabilistic with 3% Inflation	$1.9 M

1.4.3 Catch Up and Keep Up

When discussing replacement and rehabilitation, Catch Up describes all replacement and rehabilitation needs (e.g., assets fully consumed with condition score of 4 or 5) in the current year. Keep Up describes all replacement and rehabilitation needs for all of the assets in the remainder of a given planning horizon after the City has addressed the Catch Up needs. In the Catch Up and Keep Up analysis, the deterministic 30-year replacement and rehabilitation analysis is re-examined by bringing the high-risk assets (Catch Up needs) to the beginning of the planning horizon. The remaining replacement and rehabilitation needs are represented by the Keep Up. The following table displays the total Catch Up and Keep Up for a 30-year planning horizon, both represented in 2017 dollars with 30% for project delivery costs.

Table 1-7 Catch Up and Keep Up

	Cost
Catch Up	$1.7 million total
Keep Up	$ 1.4 million average per year

Overall, the Catch Up and Keep Up analysis provides a view of the future needs if the City were to focus solely on high-risk assets before addressing the other Keep Up needs. If the City were to fund the Catch Up ($1.7 million) in the immediate future, the Keep Up represents the annual average for the remaining rehabilitation and replacement needs in the 30-year planning horizon. As such, the Keep Up annual average should only be used as the future funding need estimate if the City has the budget to address all Catch Up needs in the immediate future. Otherwise, the replacement and rehabilitation analyses in Section 1.4.3 should be used as the basis for future planning.

1.5 Level of Service

1.5.1 Preferred Level of Service

The preferred level of service would be for the City to follow the rehabilitation and replacement cycles as outlined in the life cycle cost logic section of this report (i.e., full service, replace and rehabilitate all assets on schedule regardless of priority). However, due to the City's limited budget the City may prioritize assets to rehabilitate or replace.

The estimated annual budget over a 30-year horizon (Table 1-5) for the preferred level of service is approximately

$1.5 million or $2.3 million with 3% inflation.

1.5.2 Minimum Level of Service

Under the minimum level of service, only high-risk assets (i.e., CoF 4 and above), which are generally associated with street lights in high-traffic areas, would be rehabilitated and replaced. The figure below shows the rehabilitation and replacement profile over a 30-year horizon for the minimum level of service (high-risk only). The average annual need for the minimum level of service is $767,000 or $1.2 million with 3% inflation. While this annual average is much lower, operating under the minimum level of service would mean not replacing any street lights along the collector and residential roads. Because the street lights play a major role in public safety, this may not be a practical option.

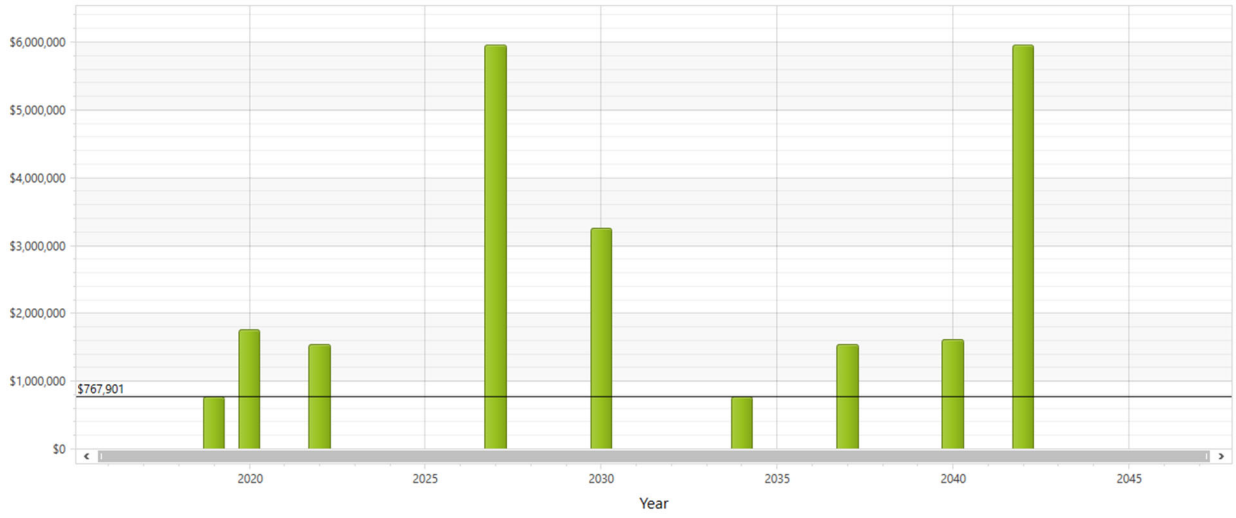

Figure 1-11 Minimum Level of Service (High-Risk Only) Replacement and Rehabilitation Profile

1.6 Management System Score

1.6.1 Physical Health

The physical health of the Street Light Management System was determined based on the ratio of poor condition assets and the high risk, red zone assets (as identified in Section 1.3) to the overall replacement cost of all system assets. These scores were used to assess the overall grade of the management system. For these scores, the lower the percentage of poor condition (Overall Condition) and high risk (Risk-Based Condition) scores, the better.

Table 1-8 Street Light Management System Physical Health Values and Scores

Category	Score	Grade
Condition Score	15%	C
Risk Based Condition	3%	A

The street lights received physical health scores of C and A, which indicates that they are estimated to be in good to fair condition overall. It is important to note, however, that these grades are based on estimated installation years that may be estimating the street lights to be in worse condition than in reality. More thorough condition assessment is recommended to estimate the true condition of the street lights.

1.6.2 Financial Health

The financial health of the Street Light Management System was judged based on the ratio of the Catch Up and Keep Up values to the 2017 annual rehabilitation and replacement budget of approximately $170,000. The scores for each category are presented below. These scores were used to assess the overall grade of the management system.

Table 1-9 Street Light Management System Financial Health Values and Scores

Category	Score	Grade
Catch Up Score	10%	F
Keep Up Score	12%	F

As shown in the table above, the financial health of the Street Light Management System is poor, with an overall grade of F indicating the City's Catch Up needs. While the assets are currently in decent condition as shown with a physical health score of C (Table 1-7), the poor catch up score means that there is insufficient funding dedicated to building rehabilitation and replacement to improve the condition of the current high-risk assets. The system also received a Keep Up grade of F; this implies that the system will not likely have the funding to keep up once is has caught up. Once again, it is important to remember that these grades are based on high-level assumptions for the ages of the street lights and could change in future assessments once condition assessment is performed.

1.7 Policy

Due to the effect of street lights on public safety, street lights should be replaced prior to failure.

1.8 Confidence Level

Confidence level factor weights are based on the City's specific goals for this phase of the asset management program development. Factors that were focused on during this phase of the asset management program development, such as asset inventory and condition assessment, were given higher weight. One of the City's particular goals was also to encourage buy-in on the part of its staff and stakeholders, so the Community Asset Management Program (CAMP) committee review was added to the general asset management program as a factor. On the other hand, factors that will be improved in future phases of the program development were given lower weight.

Table 1-10 Street Light Confidence Level

Confidence Level Factor	Confidence Level Rating Score	Weighting Factor	Weighted Confidence Level Rating Score
Asset Inventory	50%	20%	10%
Data Quality	50%	15%	8%
Condition Assessment	50%	20%	10%
Asset Valuation	75%	10%	8%
Life-cycle Cost Logic	75%	10%	8%
Risk	75%	10%	8%
Staff Review	60%	5%	3%
CAMP Committee Review	100%	10%	10%

Total Score			**63%**

Asset Inventory (Unweighted Score - 50%)

The asset inventory was based on staff knowledge and partial GIS and Excel databases. As the databases for the street lights improve, the asset inventory can be updated with a higher degree of confidence.

Data Quality (Unweighted Score - 50%)

The City is currently working to improve its street light database. At the time of this project, there were data gaps for key asset attributes, including light type, pole type, and unique IDs. As the databases for the street lights improve, the data quality can be updated with a higher degree of confidence.

Condition Assessment (Unweighted Score - 50%)

The condition assessment was based on an age analysis that followed development trends in the City. As condition assessment is performed and tracked to individual street lights, the condition can be updated with a higher degree of confidence.

Asset Valuation (Unweighted Score - 75%)

Replacement costs were estimated for each asset class. As assets are replaced in the future, the costs will be updated.

Life-cycle Cost Logic (Unweighted Score - 75%)

Life-cycle cost logic was assigned to the assets based on asset class.

Risk (Unweighted Score - 75%)

A robust CoF methodology was developed that incorporates the criticality of the street light location and the function the street light serves.

Staff Review (Unweighted Score - 60%)

Staff was involved in the development of the street light management system. Continued review of the inventory and condition assessment should happen regularly.

CAMP Committee Review (Unweighted Score - 100%)

The CAMP committee reviewed, analyzed, and provided input on the results throughout the asset management plan process.

1.9 Next Steps

Asset Inventory and Condition Assessment

As the City moves forward in improving the street light asset management system, it is important to improve the quality and completeness of the asset inventory. It is recommended the City make improvements to its street light data to include the attributes necessary for asset management analyses. These attributes include ID or badge number, light/lamp type and size, pole type, locations, and current condition. The condition scores in particular may change the future replacement and rehabilitation needs.

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The management strategies for the street light assets are shown in the following table.

Table 1-11 Street Light Management Strategies

Asset Class	Useful Life (Years)
Ornamental Pole	60
Street Light Pole	60
LED Light Fixture – Retrofit	15
LED Light Fixture – Full Conversion	15

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