DARKHORSE
EMERGENCY SERVICES

10507 Saskatchewan Drive NW, Edmonton, AB T6E 4S1

1.800.261.1832 | www.darkhorseemergency.com

FINAL REPORT

City of Kelowna Fire Plan Value Analysis

DECEMBER 6, 2017

Executive Summary

Darkhorse Analytics was engaged by the City of Kelowna to conduct a value planning analysis for the Kelowna Fire Department (KFD). The primary objectives of the study were to review the 2016-30 Strategic Plan and to provide input on:

- The need for, timing of, and location of additional stations
- The need for and timing of additional response vehicles
- Call demand growth
- Strategies to respond to growth and manage risk

To answer these questions, Darkhorse conducted a detailed analysis of three years worth of historical call patterns, developed a spatial forecast for call growth through 2030 using the City's population growth forecasts, and applied a station location and deployment model to the current and future City.

In the near term, the main concern is the high growth in call volumes. Calls have increased by 10% in each of the previous three years reaching just over 11,400 in 2016. Medical calls make up the bulk of responses (65%) and account for the majority of the growth. Breathing problems and chest pain are the two largest call categories with approximately two thousand calls per year between the two of them. Roughly half of the fire calls are minor fires and another 40% are responses to alarms.

The Fire Department uses two targets for response performance: First Due and Effective Response Force (ERF). First Due measures how quickly the department can respond with a single vehicle, and is primarily associated with medical calls. ERF is the time it takes to have sufficient personnel on-scene to begin suppression activities. KFD reaches 84% of medical calls (First Due) and 74% of its fire calls (ERF) in its target times1[1].

To understand what drives response performance in KFD, we studied the root causes of response issues and came to the following conclusion: the majority of improvement in ERF responses can be found in improving unit availability through adding resources. Right now, there is only a small portion of the City that can be reached in a reasonable time with an Effective Response Force and the service would be unable to respond to simultaneous fires effectively.

By adding a single unit to the best possible location (Enterprise station), fire response improves by over 13.5% to 86.7%. This also improves the flexibility and risk profile of the

[1] First Due Performance is % of calls reached in 9:04 Urban Non-Medical, 9:00 Urban Medical, 13:04 Rural Non-Medical, 13:04 Rural Medical. ERF Performance is % of calls reached with three suppression vehicles within 12:00 Urban, 18:00 Rural for structure fire events. The goal for all time targets is 90%.

overall system and allows KFD to better reposition resources in response to anticipated demand.

The second major item we evaluated was the need for and timing of a station location in the Glenmore area. Adding a station to the Glenmore/Hindle area improves Medical First Response (MFR) by 1.0% and fire response by 1.8%.

The best possible location for a new station is actually further south in the Glenmore Watson area. If added there, the station would improve MFR by 1.8% and fire response by 6.0%.

The timing of the new station is more difficult to analyze and is more an issue of balancing budget requirements with risk. If added in 2018, the new station would have a similar call volume as the Mission station and would be as busy as average stations in comparable communities (Strathcona County, AB and Abbotsford, BC). Furthermore, call volumes in Glenmore are expected to grow more quickly than the City as a whole.

There are a few other considerations:

- Kelowna has exceptionally high call volumes per population
- About 30% of the call volume in Glenmore is generated by two properties that may be able to reduce it (Sandalwood Retirement Resort & Highlands Retirement Residence)
- The Glenmore area (unlike the Mission area) has neighbouring stations that can provide some coverage of the community
- Flexing a vehicle into the Valley Road station at peak times would provide reasonable response performance into Glenmore

These factors suggest that there is some flexibility in the timing of adding a new station to Glenmore.

To help understand the long term picture for the City of Kelowna, we worked with the City Planning group to generate a spatial call forecast through 2030. Over the past three years, Kelowna has averaged roughly ten thousand calls per year, but also a growth rate of about 10% per year. We expect call growth to match the rate of population growth (2.3%) in our forecast and to reach just over thirteen thousand calls in 2030. We expect most of the growth to be concentrated in the Downtown and Glenmore with some additional growth in the Upper Mission and Black Mountain areas.

We can use this forecast to evaluate current stations and to see how robust the locations are into the future. We found the following:

- The downtown station would be better situated further inland near Harvey and Richter.
- A station in Glenmore/Watson is the best location for any new station both today and into the foreseeable future.

- The Mission station will eventually need to be split into two with one in Pandosy and a second in the Upper Mission.

There is significant uncertainty around demand growth. Although over the long term, calls will grow at a rate commensurate with population, Kelowna has experience three years of exceptionally high growth (~10%). Our evaluation of the data suggests that the call levels do not have a strong seasonality component and thus cannot be blamed entirely on summer tourists. Other communities have found benefit in taking active steps to prevent both medical and fire calls.

Strategies to understand and prevent calls may include:

- Identifying call hotspots and frequent users and then developing outreach programs to minimize the need for services in vulnerable communities;
- Coordinating with the BC Ambulance Service to identify events where Fire Department responses are required and should be dispatched (i.e., when an ambulance can't arrive in a timely manner) and those where an ambulance will arrive in a timely manner; and,
- Developing a risk-based fire prediction model that would prioritize certain structures for inspection and intervention

Finally, as part of the agreement, Darkhorse has provided a set of tools to use for ongoing monitoring, scenario analysis, and evaluation. With these tools, both the City administration and the Kelowna Fire Department will be better able to understand and respond to issues as they arise.

In summary, we recommend the following:

1. A new response unit should be added to the system, preferably at Enterprise Station.
2. The City should monitor call volumes - particularly in the Glenmore area - and take active steps to prevent calls citywide
3. The City should begin exploring options for a Glenmore station in the Glenmore/Watson area

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Background

The City of Kelowna engaged Darkhorse Analytics to conduct a study of the Kelowna Fire Department to evaluate its Strategic Plan, which envisions twenty new firefighters and a new station in the Glenmore area by 2020. Given the capital and personnel costs associated with the plan, the City wanted to validate the initial analysis, understand the tradeoffs associated with the investment, and incorporate changes that have occurred since the plan was developed.

The analysis comprises the following components:

- Data collection and preparation, including standardization and cleaning of project data, and a diagnostic of the relative impact of improving turnout times;
- A spatial forecast of future calls;
- Scenario analyses of optimal station locations both at present and in 2030; and
- Development and handoff of a map-based station location web tool that allows a user to adjust the station configuration and see the impact immediately.

Approach

There were three main elements to the project: Data Preparation and Historical Performance Analysis; Current and Projected Demand Mapping; and Station Location and Scenario Analysis.

Data Preparation and Historical Performance Analysis

Data received from KFD covered unit responses for the period of January 1, 2014, to December 31, 2016. The total number of unit responses in the delivered data is 39,933. Based on unique call identification numbers, there are 31,076 events in the dataset from 2014 to 2016.

To ensure that our modeling is correct, we implemented an outlier removal methodology that flags data points due to informational gaps. Beyond outliers, before analysis, the data is filtered for data that correspond to event level first-responders. Note, outliers are not removed from the reporting tools, only from the analysis used to identify Kelowna-specific parameters.

Outlier Removal Methodology

We flagged and removed outliers based on the following rules:

- Missing timestamp fields: Dispatch, En Route, On Scene

- Invalid response time intervals: null or negative response times for: Incident, Dispatch, En Route, On Scene, In Service, and In Quarters
- Missing XY coordinates
- Unknown apparatus station
- Duplicate records

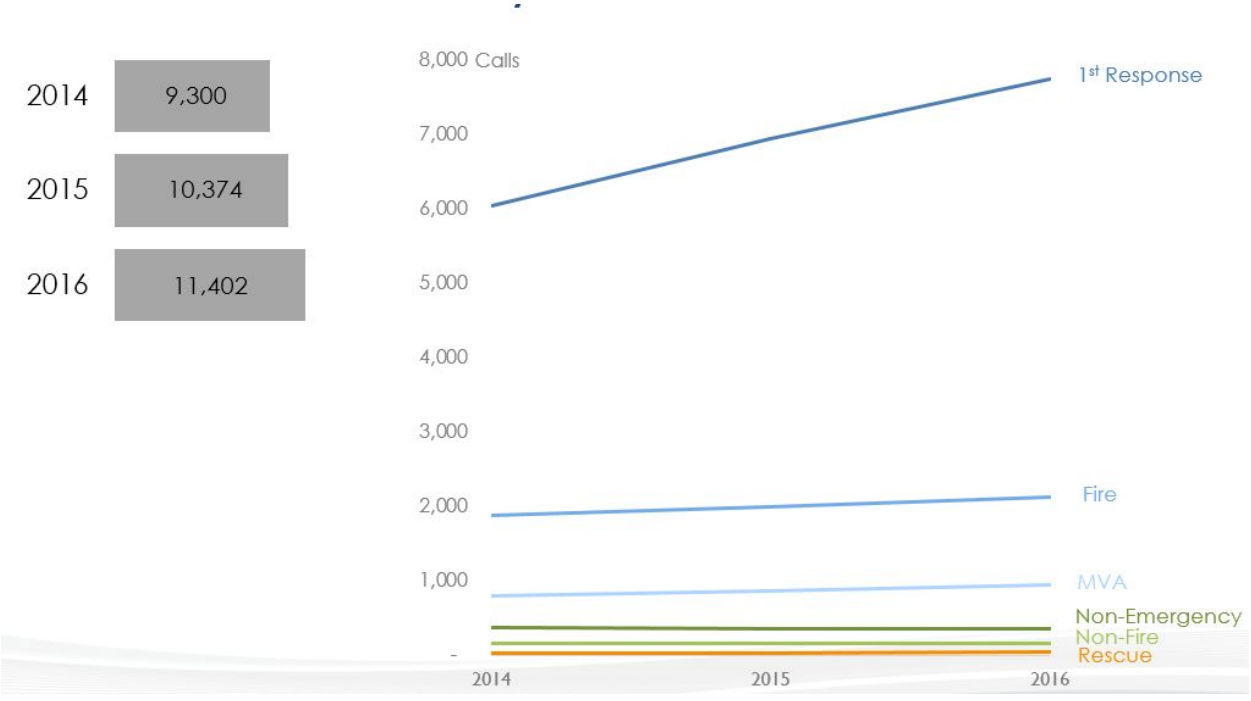
Cancelled Call Removal Methodology

We also removed calls that were cancelled en route as determined by missing On Scene timestamps.

Ultimately, we were left with 29,527 events for our analysis from the initial count of 31,076. Unit responses that are not cancelled or removed as outliers are considered as “valid responses” in the data.

Call Demand Analysis

The following analysis examined the growth rate and composition of service demand over the past three years. Demand has increased by more than 10% per year and is primarily driven by a surge in medical calls. Other call types, such as fire, MVA, and rescue are also growing, but at a rate of 1-5%.



When evaluating the fire department's workload against comparable services in Canada, it is apparent that Kelowna responds to nearly double the events per career station as other jurisdictions. This is suggestive of a need for more resources, particularly given that an additional station in Kelowna would only reduce the average incidents per station to 1,900 events/year, an amount still higher than any other department. That said, Kelowna has a far more concentrated call profile with the vast majority occurring in the downtown and highway corridor.

Municipality	Avg Incidents/FT Station/Year
Kelowna	**2,460**
Abbotsford	1,640
Strathcona County	1,189
Toronto	1,307

Performance Targets

This analysis focuses on measuring performance by time standards, which is the generally accepted method of performance reporting for emergency service providers and is the basis for the station location optimizations in this study.

Time-based performance reporting specifies a 90th percentile target time where a service works to achieve 90% of first unit responses in less than the chosen standard. KFD has outlined a turnout and travel time of 8:00 within the urban area, and 12:00 in the rural area. Adding the National Fire Protection Association (NFPA) benchmark for call evaluation time gives us a total response time of 9:04 in the urban area, and 13:04 rural for fire calls. Medical calls have a reduced alarm target of 60 seconds within the urban area, giving a total response target of 9:00 for urban. Medical calls also have a 13:04 target in the rural area.

KFD uses a more aggressive travel target time than the NFPA in their rural areas, but travel time targets are 2 minutes longer than NFPA standards within the urban area. Individual response time components are further broken down by the NFPA guidelines, and these have been applied in our diagnostic analysis to identify the drivers of late responses. The following table summarises the response time standards.

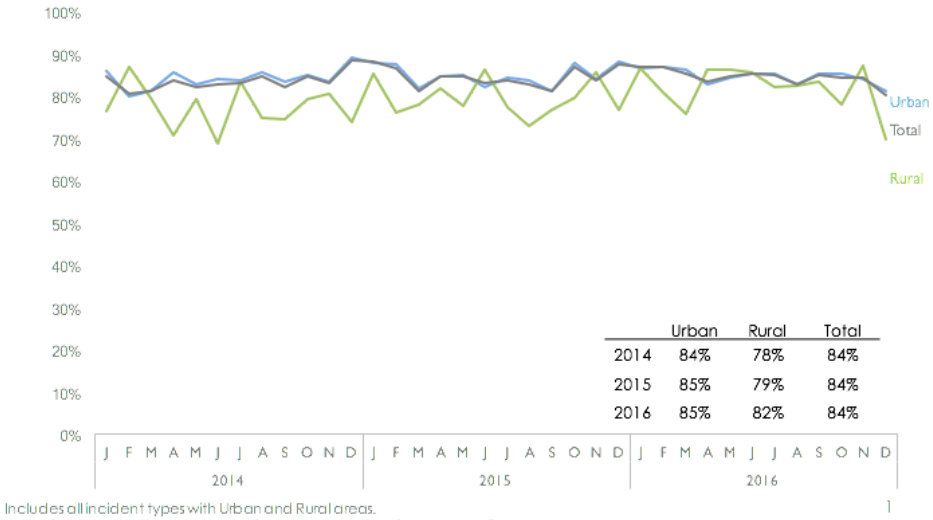
Response Component	KFD Targets		NFPA Standards	
	Urban	Rural	Urban	Rural
Call Evaluation	64	64	64	64
Medical	60	64	64	64
Turnout	120	120	80	90
Medical	120	120	60	60
Travel	360	600	240	686
Total Response	544	784	384	840
Medical	540	784	364	810

Historical Performance

Historical performance was evaluated comparing the geography type of each incident location as well as comparing incident types. These are depicted in the following figures. Note, for this section, we speak specifically of First Due performance which measures that time it takes for the first vehicle to arrive on scene. First Due performance is driven mainly by vehicle proximity - i.e., station locations. It is most appropriate when considering medical calls. The Effective Response Force metric will be addressed in the Fire Performance section that deals more with suppression unit requirements.

Performance Through Time by GeoType

(First on Scene)



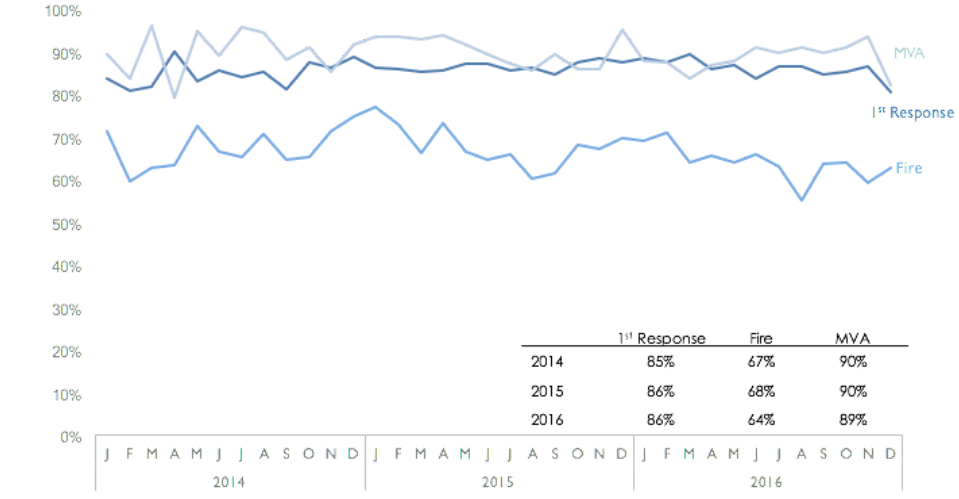
	Urban	Rural	Total
2014	84%	78%	84%
2015	85%	79%	84%
2016	85%	82%	84%

Includes all incident types with Urban and Rural areas.
Excluding cancelled responses, spatial and temporal outliers, and duplicates

1

Performance Through Time by Incident Type

(First on Scene)



	1st Response	Fire	MVA
2014	85%	67%	90%
2015	86%	68%	90%
2016	86%	64%	89%

Excludes Rescue, Non-Fire, and Non-Emergency incidents.
Excluding cancelled responses, spatial and temporal outliers, and duplicates

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Analysis of call data reveals yearly performance is relatively stable and that variations month-to-month are more common in rural areas due to the lower demand volume. Given the larger volume of calls within the Urban area, overall performance is primarily driven by

Urban performance. When comparing performance by incident types, medical and MVA responses are relatively consistent over time and have a higher performance than fire events.

Response time Drivers

We analyzed response time components to understand better the underlying drivers of performance. We found that response times were primarily driven by driving, distance, alarm, and turnout problems. The first two issues indicate either suboptimal station locations or the potential for service improvement from additional stations. From an operational standpoint, improving turnout times has a significant impact on response performance and should be targeted in tandem with adding resources.

For an in-depth analysis of response time drivers, please refer to the appendix.

Current and Forecasted Demand Mapping

Call Forecasting

The City of Kelowna provided Darkhorse with the Kelowna OCP Growth Masterplan, which spatially defined the current and expected population for the region, as well as the changes in land use development from the present day until 2030.

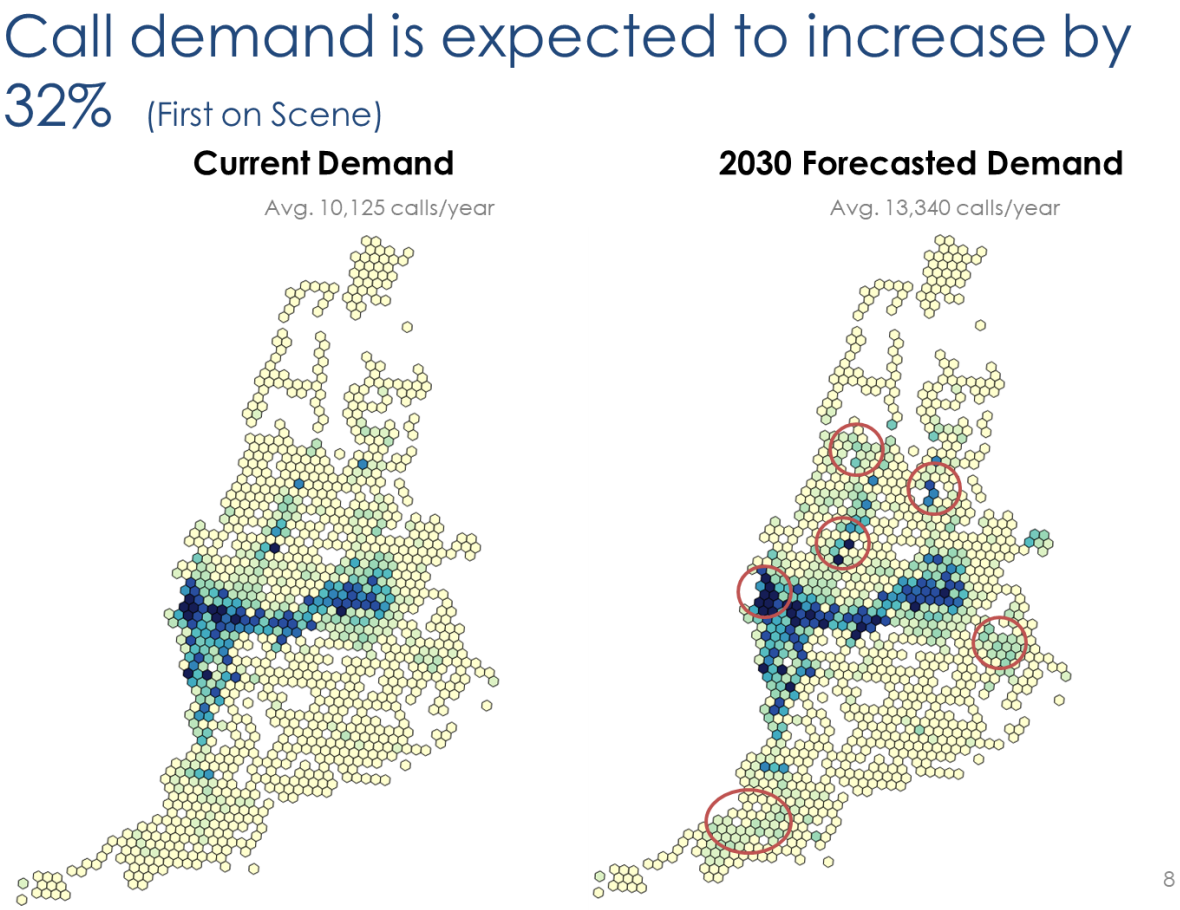
We forecast growth in call volumes according to the expected population increase, applying a call ratio per person to determine the total expected future demand. The growth study indicated that the City is projected to increase from 130,750 to 161,701 residents, all of which will be accommodated within the current city limits. Based on historical event-level data, the average ratio of valid calls/person/year is approximately 0.08. This suggests that the current average of 10,125 calls/year is expected to increase to 13,340 calls/year by 2030.

To spatially distribute the future call demand, we first calculated the calls per land unit for each of the land use types and applied these ratios to the future land use assignments. This allowed us to determine the change in call demand attributed to changes in land use designation. These ratios are listed in the table below.

Land Use Designation	Calls/Year/area
Agricultural	0.1679
Commercial	0.4572

Comprehensive	0.3339
Health District	0.3161
Industrial	0.5425
Public	0.2536
Rural	0.1262
Urban	0.2404

The remaining call demand was attributed to population changes and was spatially allocated proportionally against the overall population numbers as expected by the distribution of future single and multi-unit dwelling developments. Combined, our forecast indicates a substantial growth in population, and therefore calls, in the downtown core and by Glenmore. The changes in the spatial distribution of calls are depicted in the following figures.



Station Location Optimization

Our station location model is a stochastic p-median model that incorporates both arrival probability and response variability (Budge, Ingolfsson & Zerom, 2008). Historical data is analysed to build an accurate picture of the actual speeds at which units travel (Budge et al., 2010).

Using the described models, we optimally located stations under five scenarios. The scenarios were evaluated assuming that the service is hitting a combined setup time of 184 seconds. This is comprised of the NFPA 64-second call evaluation target and an adjusted turnout target of 120-seconds, acknowledging that the stated NFPA 90th percentile turnout time is too aggressive for most fire services. Rather than using the service's actual setup times, this assumption of meeting the 184-second standard ensures that we are not misinterpreting an operational issue with a more costly station coverage issue. As a result, we see slightly higher performance values here than those displayed in the diagnostic analysis since the model assumes fewer call evaluation and turnout time problems. The model also assumes no busy problems with apparatuses always available at each station.

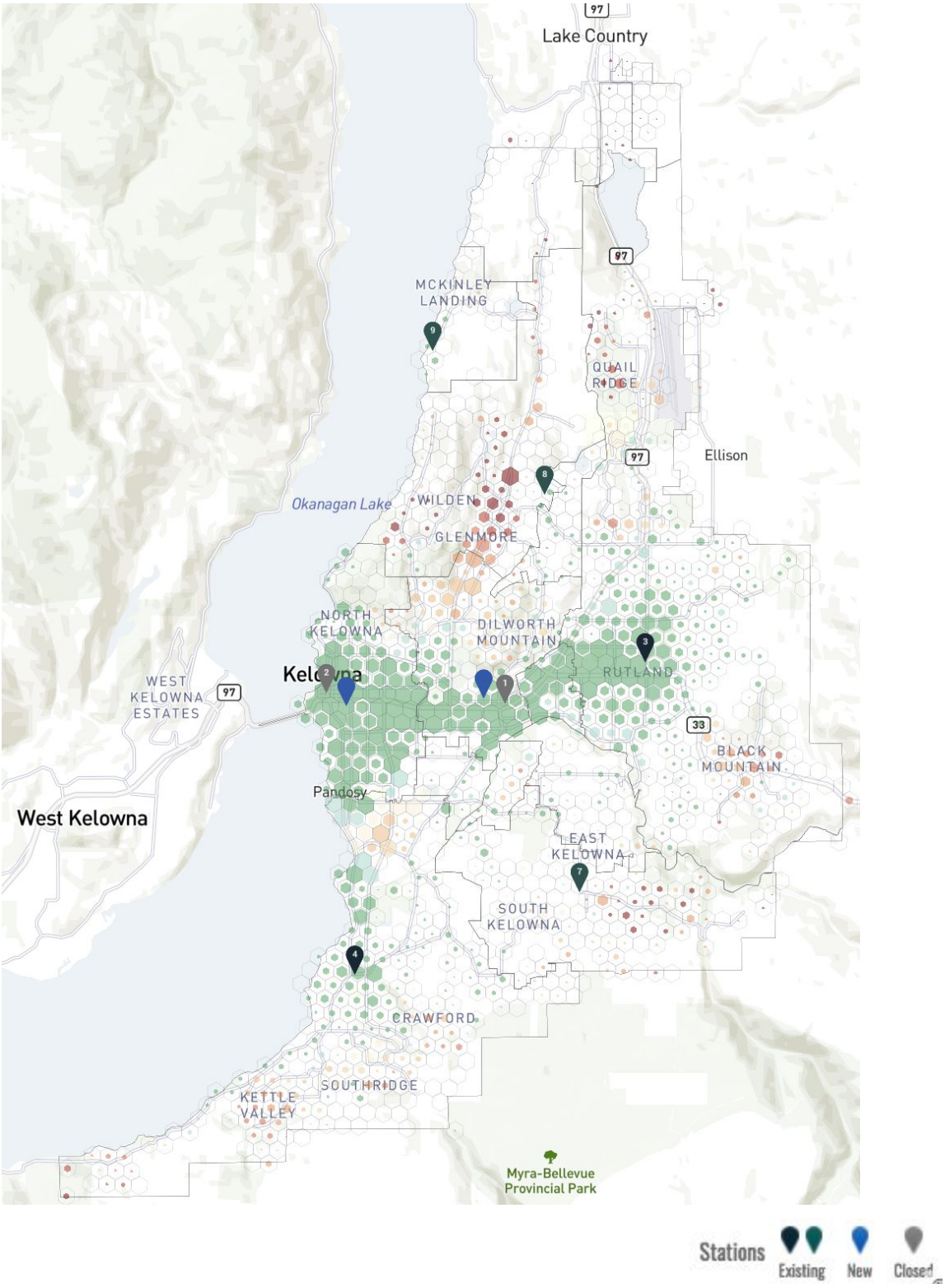
The four scenarios that form this study include:

1. Four full-time career stations in optimal locations
2. Five full-time career stations (Halls 1-4, Hall 5 in Glenmore)
3. Five full-time career stations (Halls 1-4, optimal location for Station 5)
4. Optimal location for six stations given current locations Enterprise and Rutland

For each of these, we report the medical call performance (First Due) since the fire performance (ERF) can change substantially depending on whether stations are single or multiple unit. In other words, this part of the analysis is to sort out the proximity issues. Unit availability can be tackled as the City's growth comes into clearer focus.

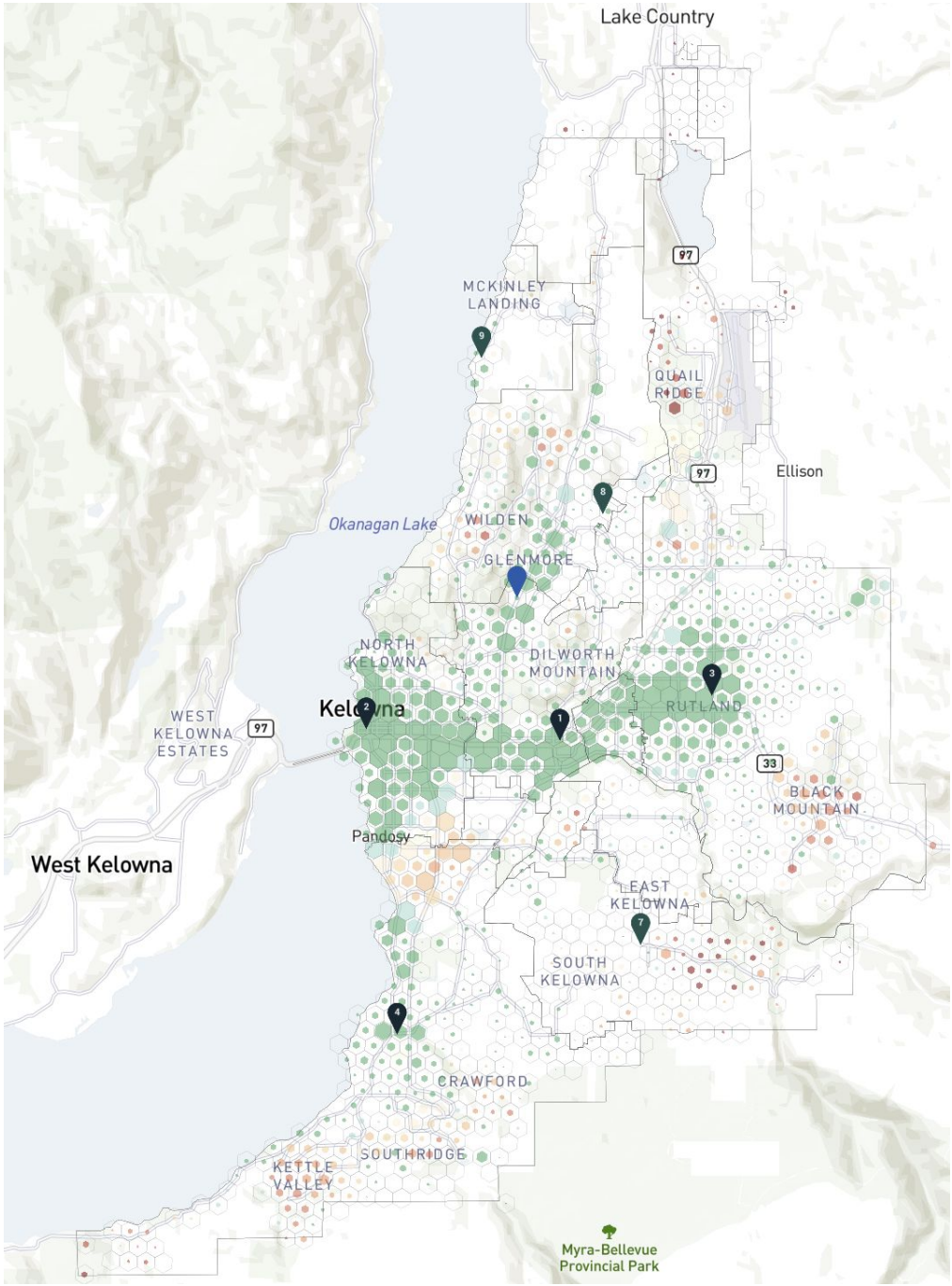
Existing Full-Time Stations

KFD wanted to understand how the current stations compared against the optimal locations. We used the forecasted (future) demand to optimize the station placements. The resulting solution moves stations 1 and 2, but leaves the Mission and Rutland stations in the same location. However, the relocations of stations 1 and 2 were relatively trivial. This suggests the current locations are nearly optimal. This improved current performance from 90.1% to 90.8%. These station placements also demonstrated improvements in the future state, raising the expected performance from 89.2% to 89.8%.


Lake Country
97
MCKINLEY LANDING
QUAIL RIDGE
Ellison
Okanagan Lake
WILDEN
GLENMORE
NORTH KELOWNA
DILWORTH MOUNTAIN
RUTLAND
WEST KELOWNA ESTATES
33
BLACK MOUNTAIN
Pandosy
West Kelowna
EAST KELOWNA
SOUTH KELOWNA
CRAWFORD
SOUTHRIDGE
KETTLE VALLEY
Myra-Bellevue Provincial Park
Stations
Existing
New
Closed

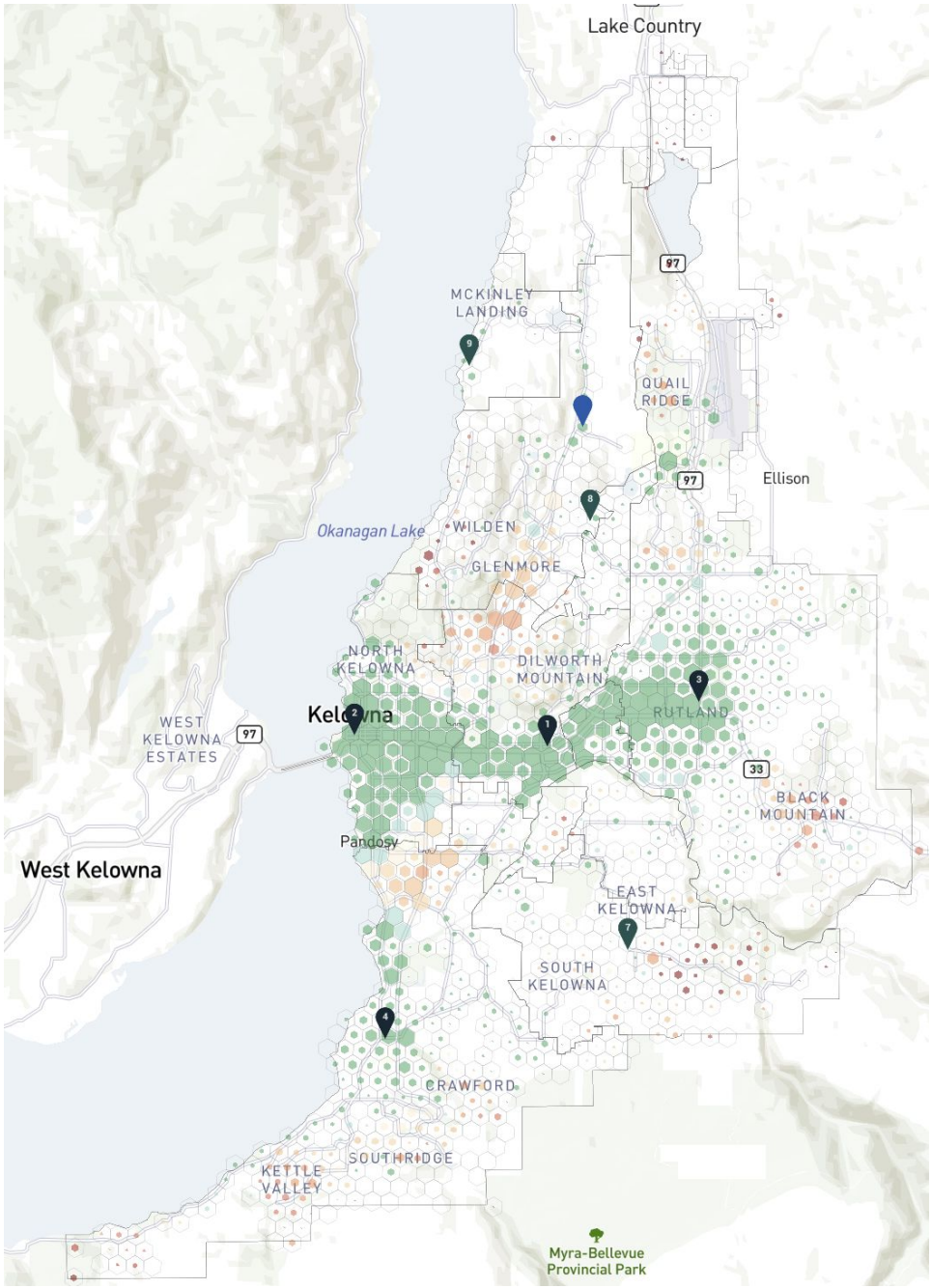
Existing plus Glenmore/Watson

This scenario assesses the optimal location of an additional full-time station, assuming existing full-time and auxiliary stations remain the same. The solution suggested a station near Glenmore/Watson to improve coverage as the northern portion of the city continues to expand. Adding a station in this location improves future performance from 89.2% to 91.4%.



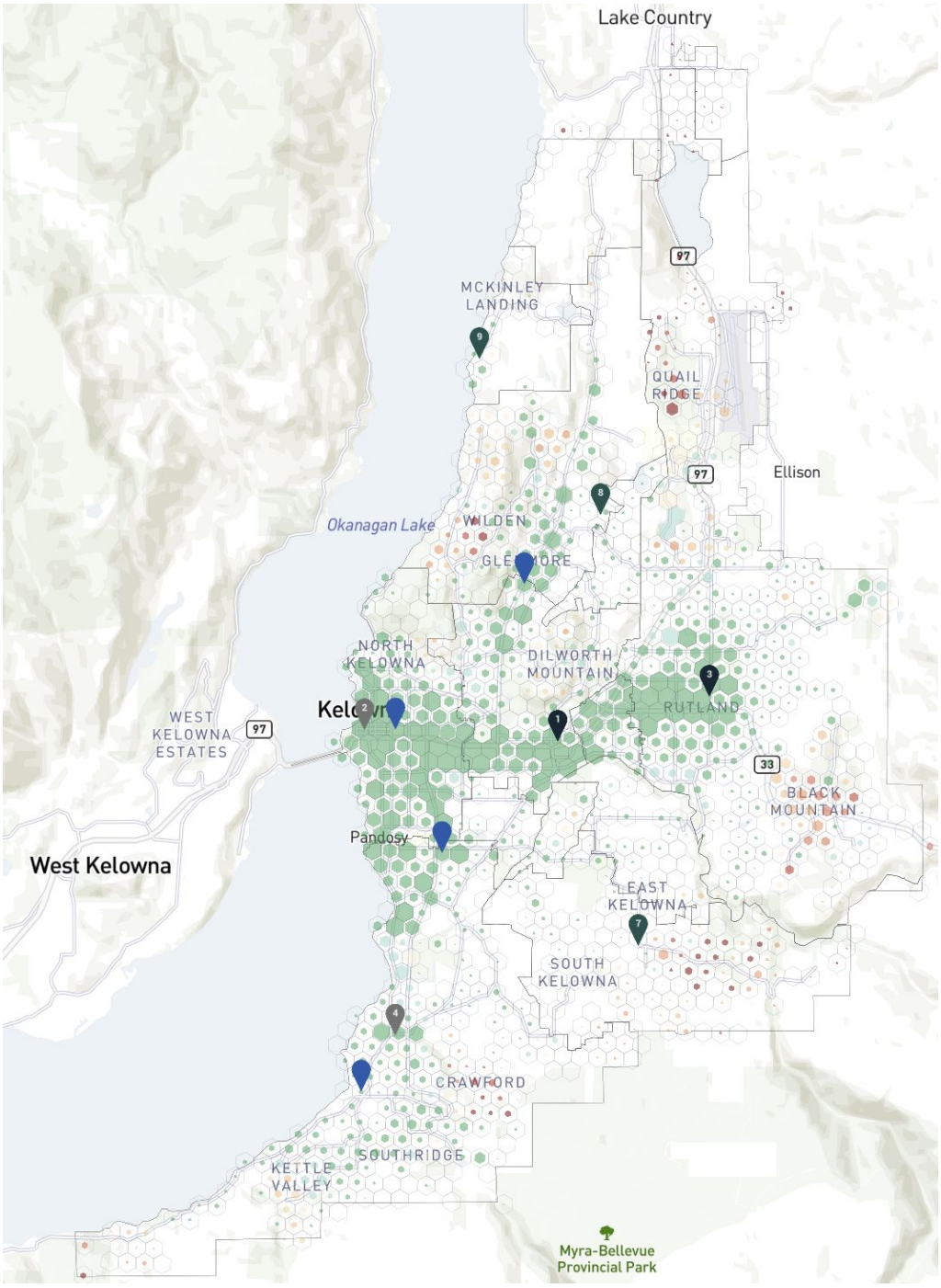
Existing plus Glenmore/Hindle

This scenario assesses the impact of adding a new full-time station in the Glenmore Hindle Road area. This location improves future improvement from 89.2% to 90.8%.



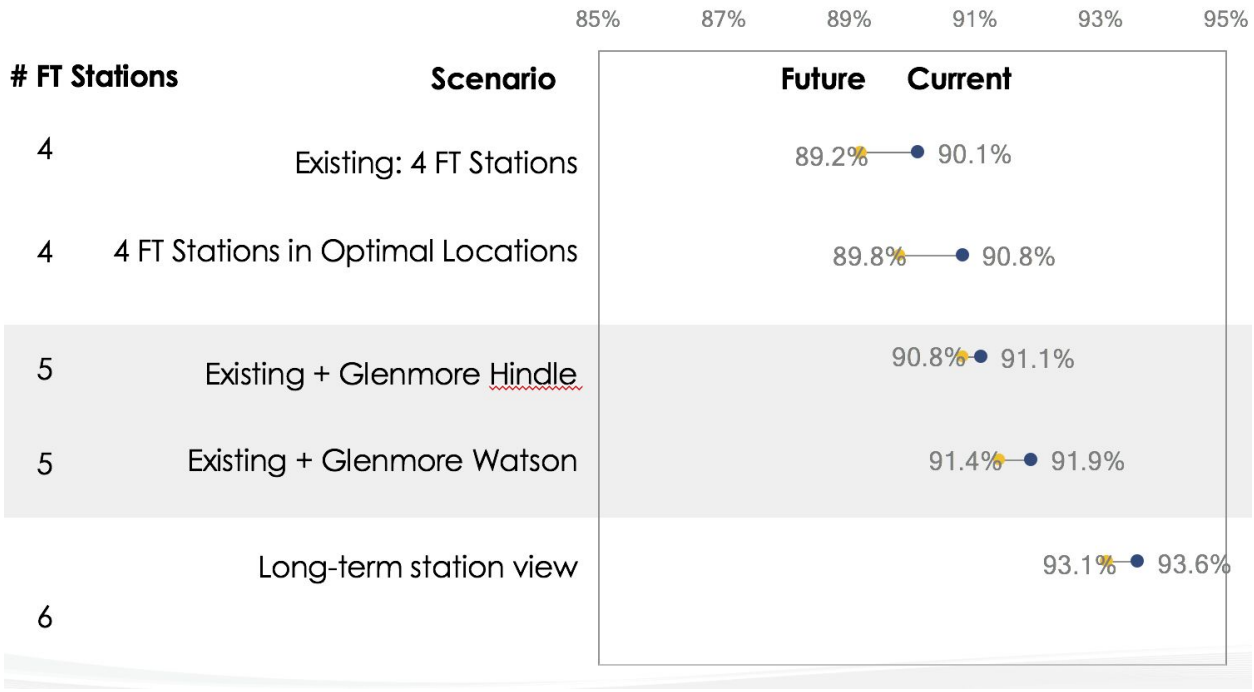
Long-term Station View

This scenario assessed a most likely future state whereby Kelowna has six full-time stations. The most important change is a new station at Glenmore/Watson, followed by a splitting of the Mission station into two - one in Pandosy and one in upper Mission. Finally, the Downtown station is moved further inland toward Richter Street. The result of these changes is improved First Due performance: 93.1% from 89.2%.



Station Scenario Summary

The following figure compares the expected performance for each station scenario under the current and forecasted call demands.

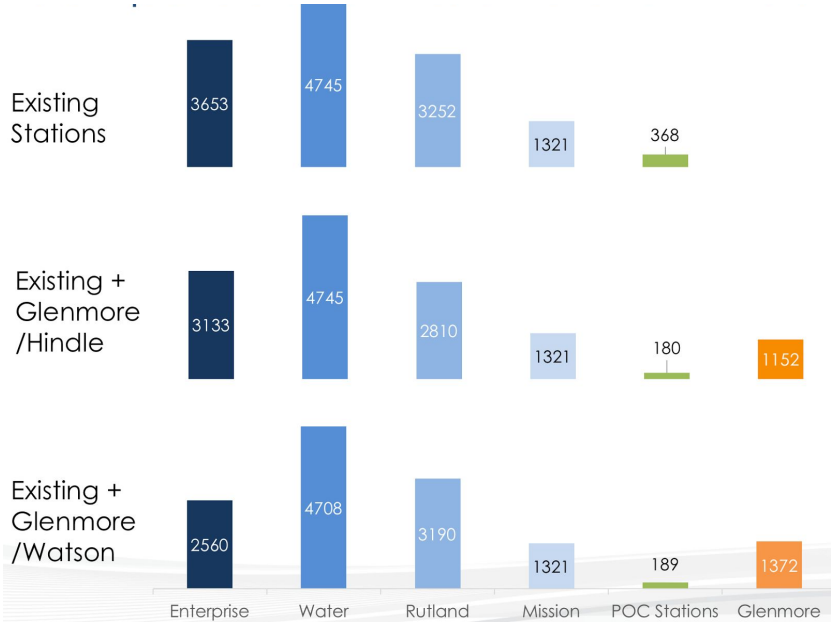


Station Timing

In our analyses, it is clear that the next station added should be placed in the Glenmore region - preferably near Glenmore and Watson. What is not so clear is the timing. In looking at average calls per station in Kelowna as compared to a set of communities, Kelowna is far busier.

Municipality	Avg Incidents/FT Station/Year
Kelowna	**2,460**
Abbotsford	1,640
Strathcona County	1,189
Toronto	1,307

Furthermore, in looking at how busy a new station in Glenmore would be, we can see that it would face a workload equivalent to the current Mission station.



Thirdly, given the City's population growth expectations, we forecast call growth in Glenmore to be higher than the city average (~50% as compared to ~30% by 2030).

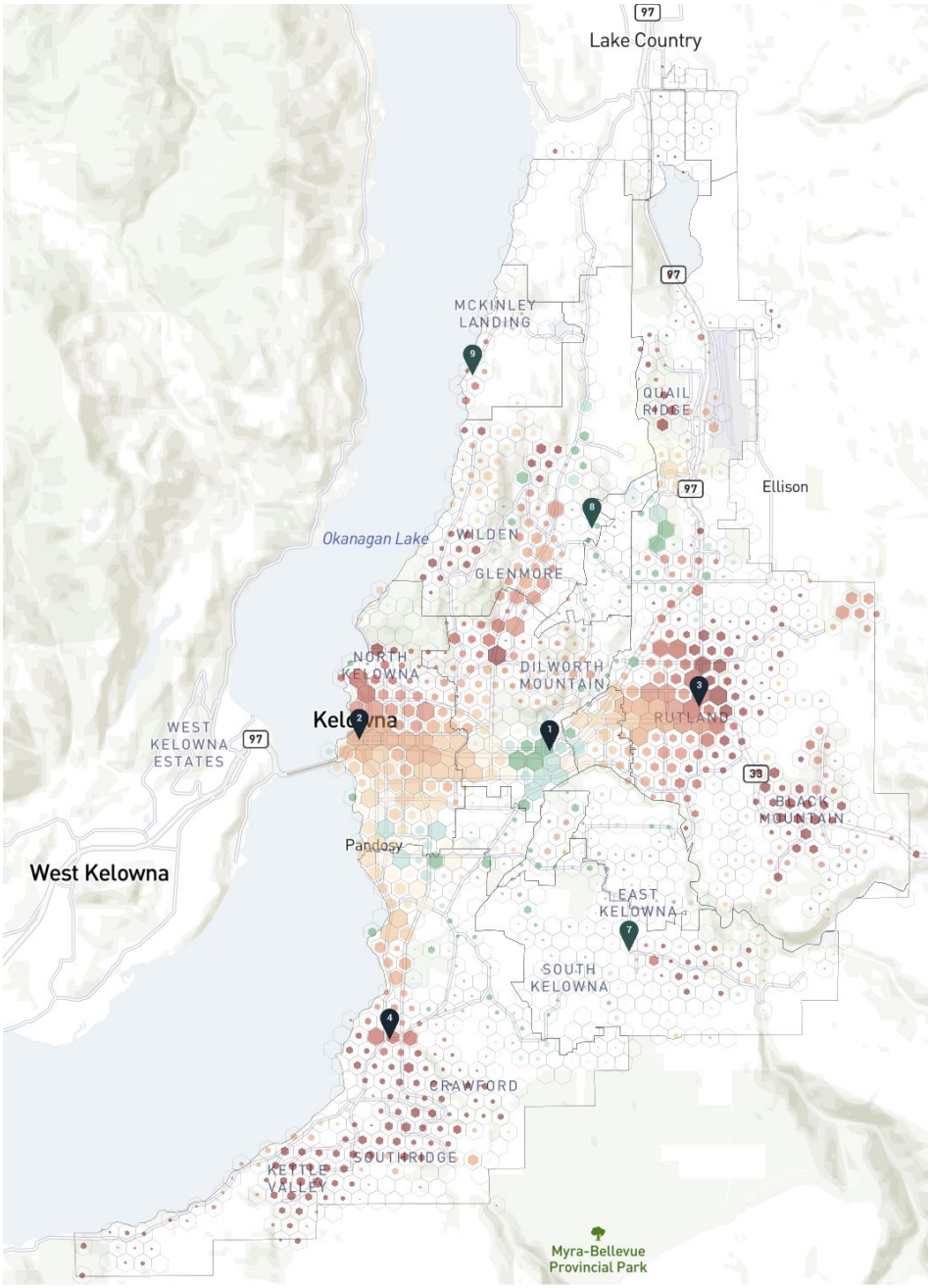
On the other hand, there are some factors which suggest a slower approach is warranted:

- Kelowna has exceptionally high call volumes per population. If these can be reduced, it may delay the need for a station in the near term;
- About 30% of the call volume in Glenmore is generated by two properties that may be able to reduce it (Sandalwood Retirement Resort & Highlands Retirement Residence)
- The Glenmore area (unlike the Mission area) has neighbouring stations that can provide some coverage of the community; and
- Flexing a vehicle into the Valley Road station at peak times would provide reasonable response performance into Glenmore

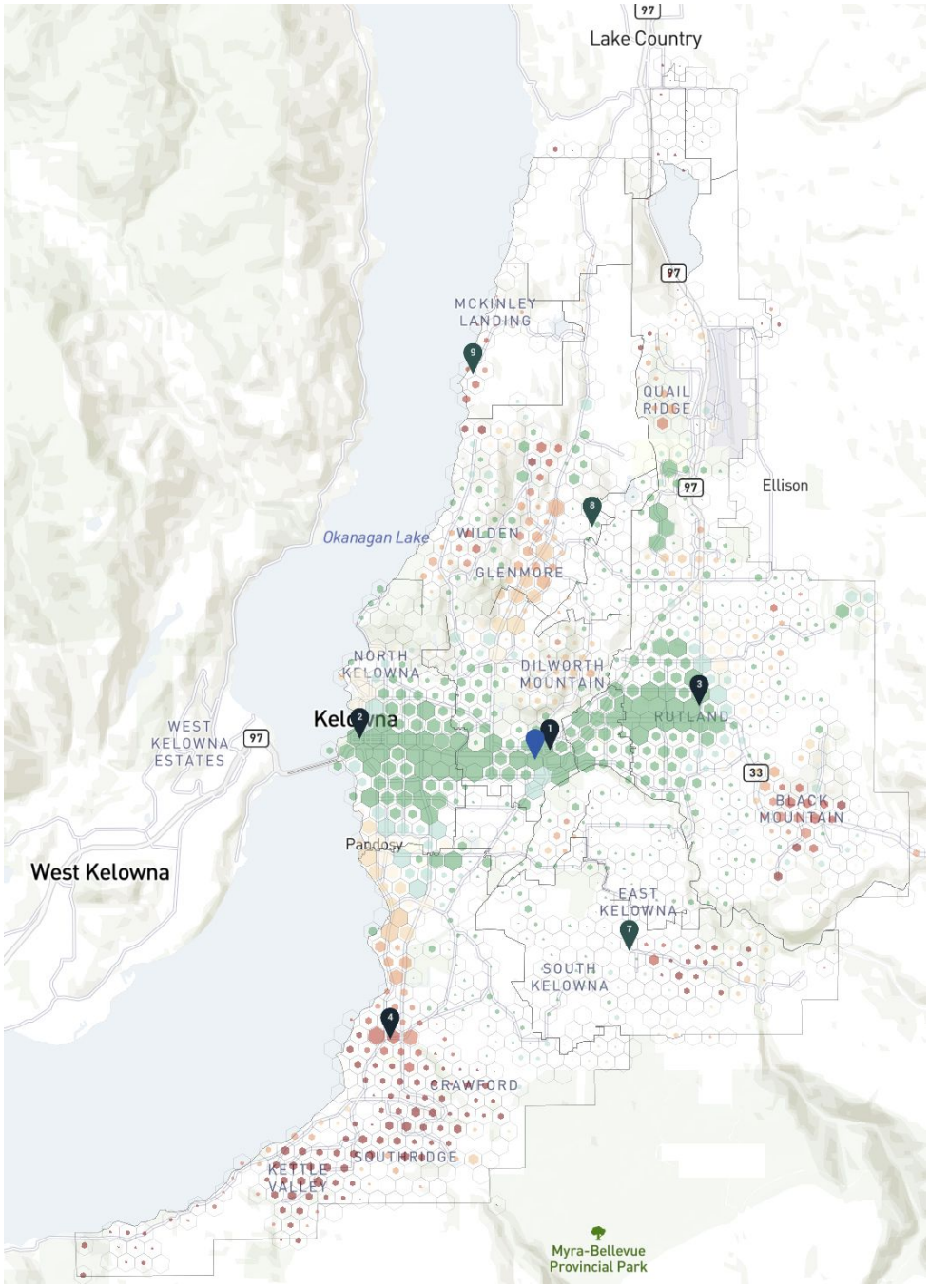
In summary, a station will be needed in Glenmore sometime in the next several years. We suggest an approach that mitigates calls through active prevention, monitors call volumes to the area, and reduces risk through active redeployment when appropriate. If calls continue to grow in spite of these efforts, then we suggest that adding a station is warranted.

Resourcing and Fire Performance (ERF)

Fire suppression effectiveness is best measured by Effective Response Force (ERF) performance. This is the percentage of calls reached in 12 minutes in urban areas and 18 minutes in rural areas with three full suppression units. The Kelowna Fire Department aims to reach 90% of calls in this target, but is currently reaching 74%. The following map shows the current ERF (Fire response) performance. Only a small area around the Enterprise station and another near the airport can be reached in the target time.



Adding a unit to the Enterprise station has a dramatic result. The map below shows the impact on fire performance. Notice that the high call volume corridor between the airport and the lake is completely covered with the addition of a single unit to Enterprise.



We ran a number of additional scenarios which are summarized in the table below:

Scenario	Fire Performance	
Existing	**73.2%**	
Add 2 units to Station 1 & 2	87.8%	+14.6%
Add 1 unit to Station 1	86.6%	+13.4%
Add 1 unit to Station 2	81.6%	+8.4%
Add 1 unit to Station 3	80.4%	+7.2%
Add 1 unit to Station 8	76.1%	+2.9%
Add 1 unit to Station 4	74.0%	+0.8%

As can be seen above, adding a single full-time unit to the Enterprise station (Station 1) has the largest impact by a wide margin. Enterprise is the most central station and additional resources there are able to help throughout the Highway 97 corridor.

Demand Management

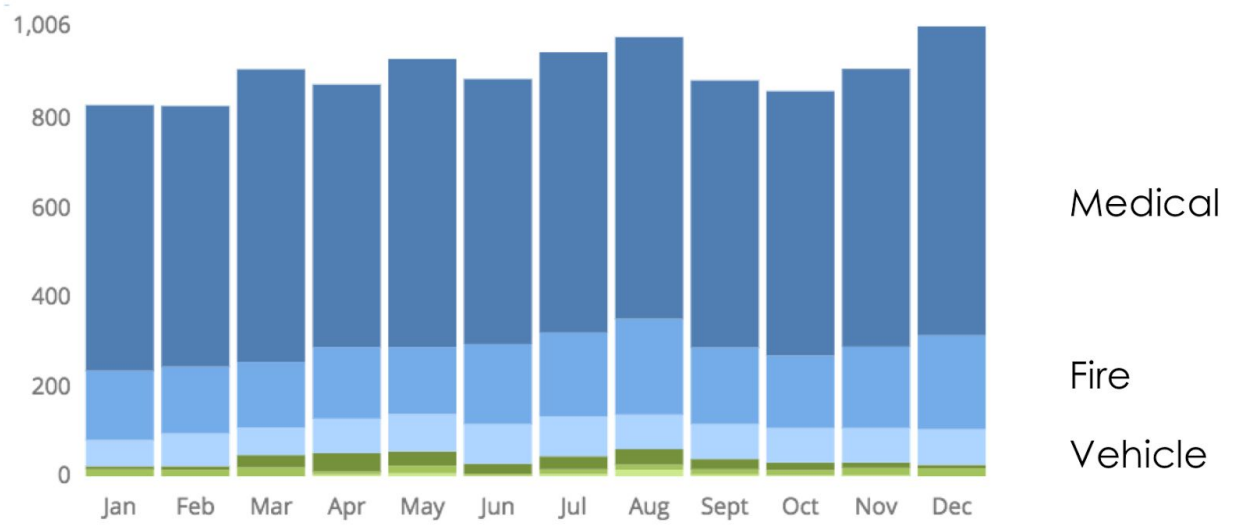
The majority of the analysis thus far is focused on optimizing the resources necessary to serve the City of Kelowna. In essence, we have been evaluating and improving the supply side of the equation. But equally important is a focus on the demand side of the equation.

Kelowna's call demand is higher than comparable communities. The table below summarizes some benchmark communities that we have worked with recently:

Municipality	Incidents/ Person	Medical Calls/Person	Fire Calls/Person
Kelowna	**0.08**	**0.05**	**0.03**
Abbotsford	0.05	0.03	0.02
Strathcona County	0.04	0.03	0.01
Toronto	0.04	0.02	0.02

Note that Kelowna has Medical and Fire calls/person between 50% and 100% higher than these comparables. Additionally, it appears that the calls are not driven by the influx of tourists over the summer. The chart below shows the monthly call volumes by type. The seasonality impact is similar to what is seen in other jurisdictions.

Monthly Call Volumes 2016



Many communities have found it beneficial to reduce calls through targeted prevention activities. As a starting point, we suggest that Kelowna take a deeper look at the call data to identify “frequent flyers”, facilities with multiple false alarms, structures with higher fire risk profiles, and other identifiable call drivers. Each of these groups will have different interventions from engaging social workers, increased false alarm fees, targeted fire inspections, etc. Additionally, there are opportunities to better coordinate response with the BC Ambulance Service.

Recommendations

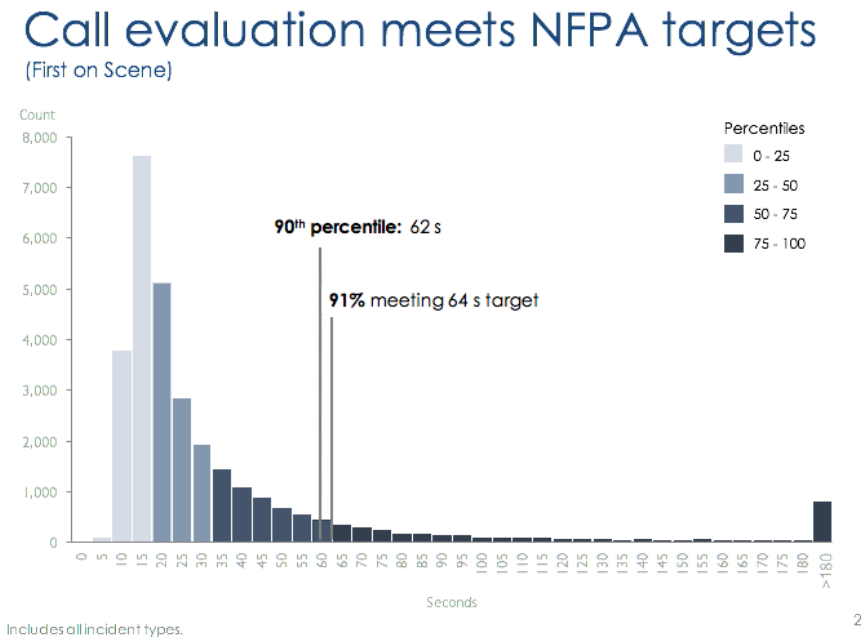
In reviewing the data provided and the output of our models, we have three main recommendations with respect to the Kelowna Fire Department:

- Add a suppression unit to the KFD fleet, preferably deployed to the Enterprise station
- Begin actively reducing call volumes through targeted inspections and other approaches
- Work with BC Ambulance to better coordinate dispatch
- Monitor call volume in the Glenmore area to see if mitigation efforts can outpace call growth
- Begin planning for a station close to Glenmore/Watson

APPENDIX

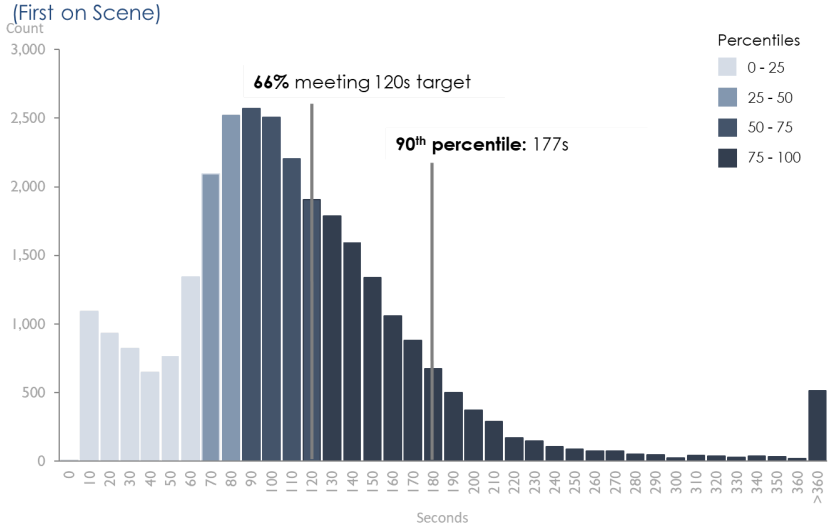
Time Interval Distribution Analysis

The following are distributions of the call evaluation, turnout, travel, and total response time from the beginning of the call to the on scene timestamp for the cleaned data. These distributions provide a broad characterization of the performance of the Kelowna Fire Department. Response times follow a lognormal distribution, as is expected of this data, and is similar to that of other services.



Turnout times are twice as long as the target

(First on Scene)

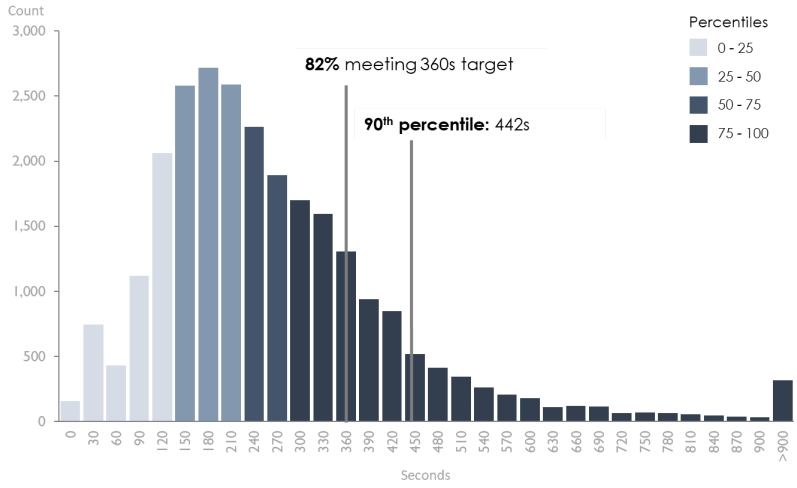


Includes all Incident Types.

4

Travel Time Distribution - Urban

(First on Scene)

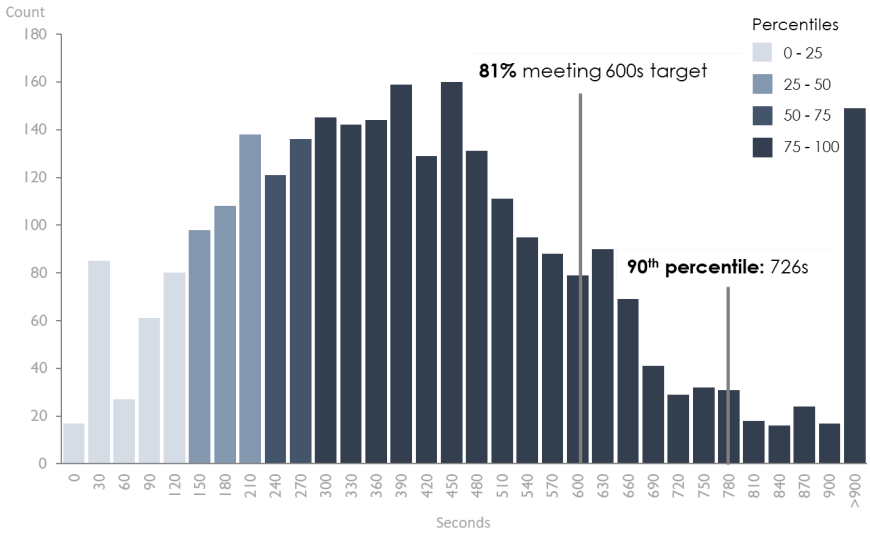


Includes all incident types.

4

Travel Time Distribution – Rural

(First on Scene)



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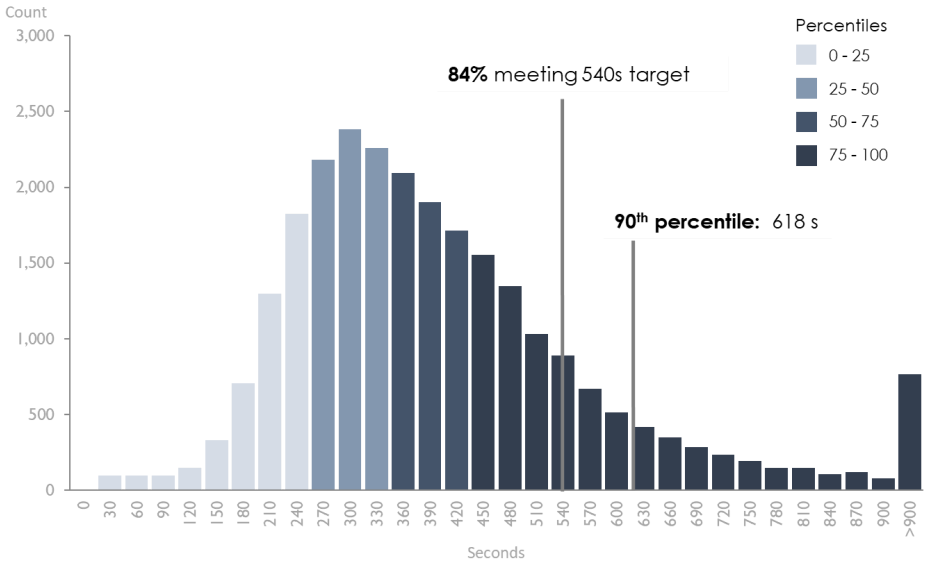
Includes all incident types.

Total Response Time – Urban

(First on Scene)



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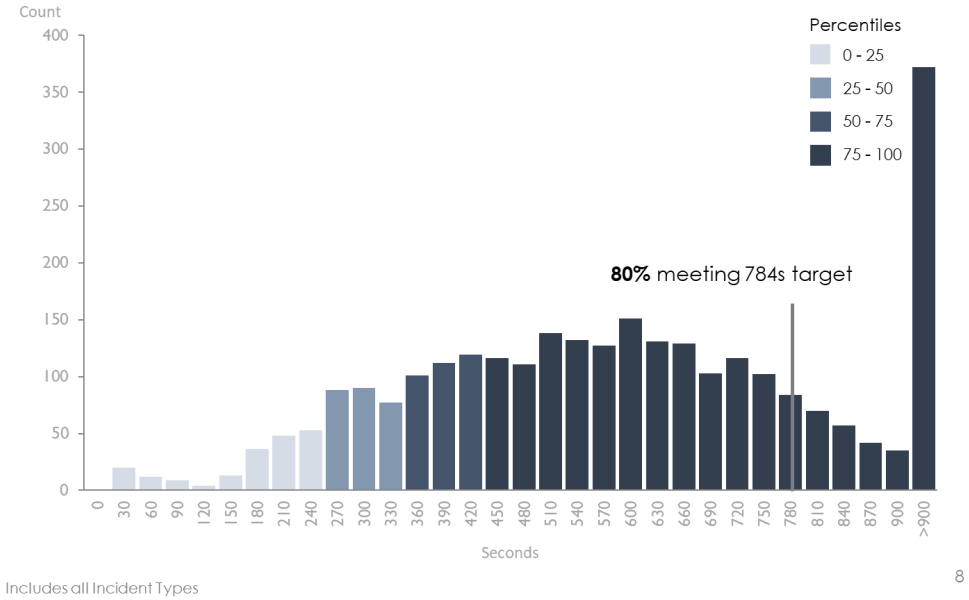
Includes all Incident Types

Total Response Time – Rural

(First on Scene)



Includes all Incident Types

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Overgoal Call Analysis

There are several contributing factors to overgoal calls. Each can be categorized loosely within operational, station location, and availability issues. Each call is categorized by the root cause that is primarily responsible. In the case of a tie, choose the cause that is most easily addressable.

Operational Issues

The operational issues comprise events which have a call evaluation and/or turnout time sufficiently over the target value, where the difference between the target and actual values pushed the call over goal.

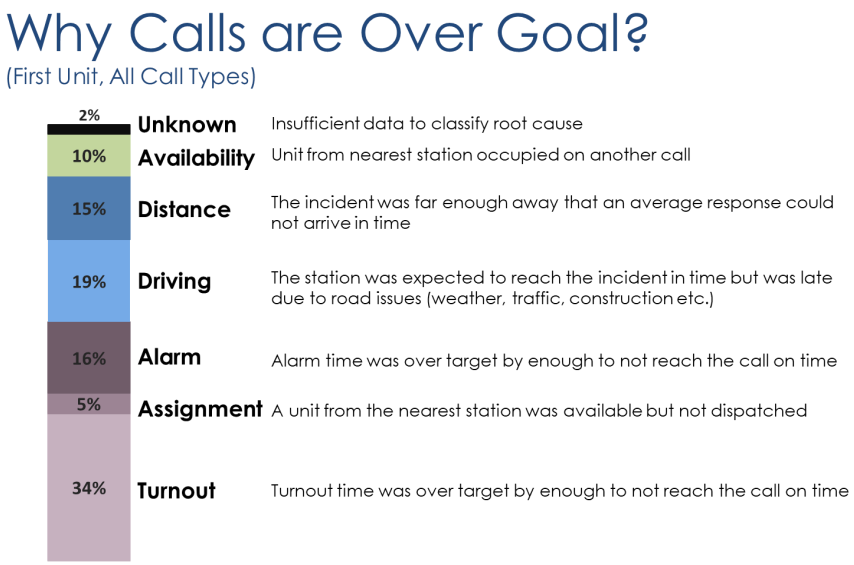
Station Location Issues

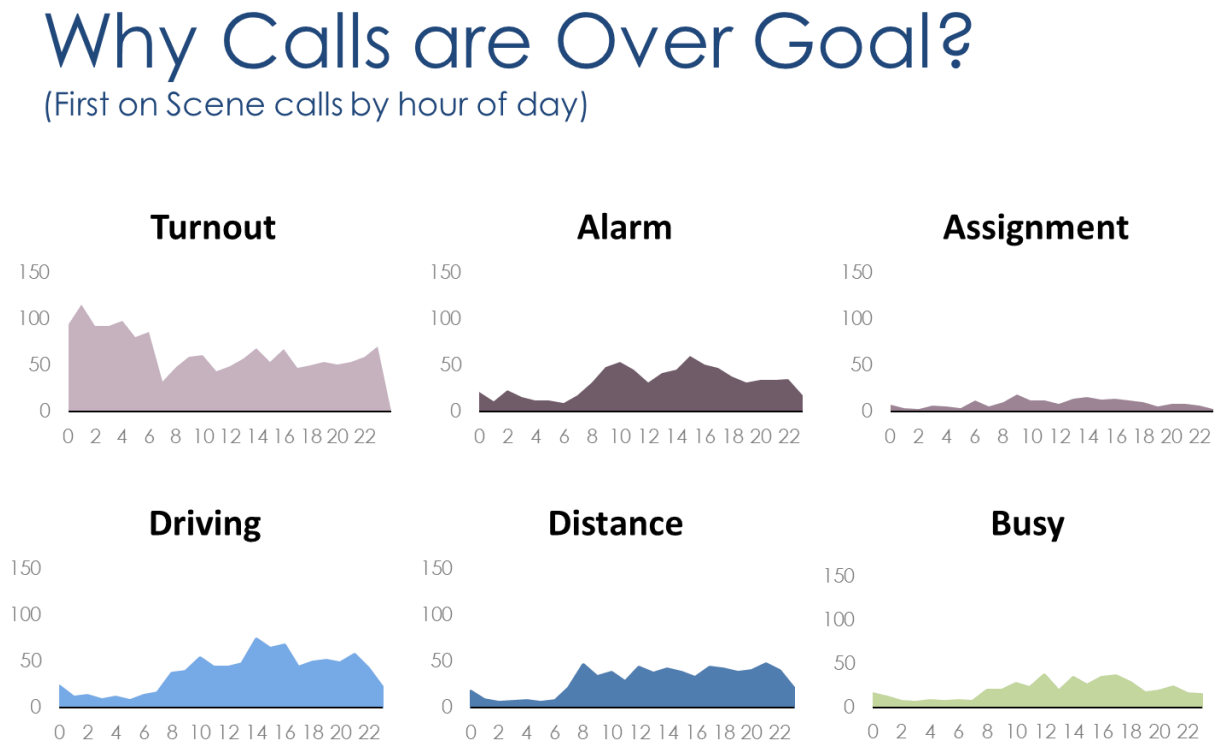
Station location issues occur when calls are overgoal because the average response is greater than the target response time, or the travel time pushed the call beyond the target. Distance problems occur when stations are simply too far from the incident to have arrived within the target, whereas driving problems are likely due to environmental factors (e.g. traffic, weather, construction) or taking a sub-optimal route.

Availability Issues

Availability issues occur when a unit from the nearest station to the call was not available and another unit from a different station was dispatched instead. Limited availability or busy units could be caused by the timing of call arrivals, overly long scene times, or insufficient units.

The following figure summarizes the primary drivers of the service's overgoal responses.





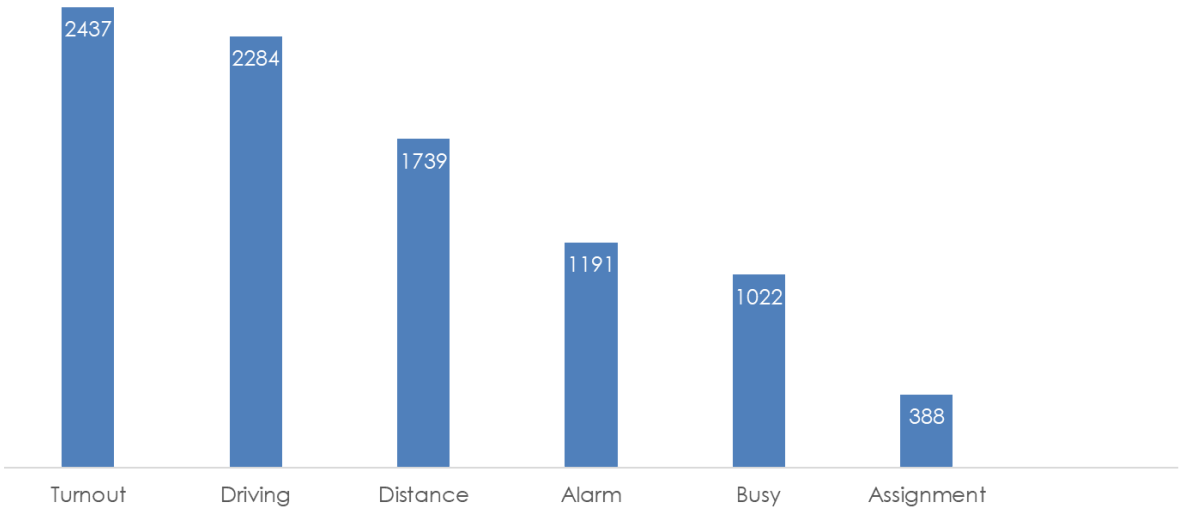
Multi-Problem Analysis

Late call analysis identifies the primary problem for each call which exceeded the total target response time. However, in many cases, there were further problems in addition to the root cause, such that the call would have still been over-goal even if the primary problem were solved.

An initial analysis was done to identify which problems were most common. For example, 2437 of the 4666 late calls, or about 50%, had turnout problems, although only about 1578, or one third of the calls, had turnout problems as the root cause. This tells us that there are about 800 calls which were late for multiple reasons, including turnout problems.

We can also see Driving problems affect about half of our calls, though are the root cause about 20% of the time. This tells us that while Driving problems are prevalent, they are not having as much of an impact on total response time as are other factors.

Multi-problem Analysis



Of 4666 calls which were late, what were the problems?

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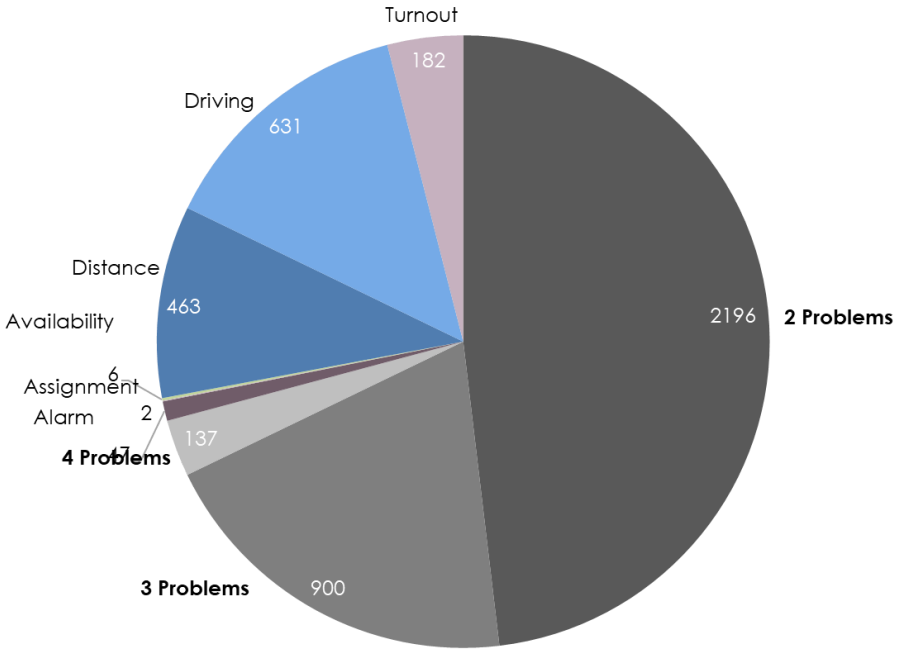
70% of calls have multiple problems



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References

Budge, S., A. Ingolfsson, D. Zerom (2010) Empirical analysis of ambulance travel times: The case of Calgary Emergency Medical Services. Management Science 56 716-723