

Analysis Metric:

AIR
QUALITY

Presenter:

Dan Heiser
Engineering Manager



Air Quality

- Air quality standards and changes after 1997
- Regional monitoring data shows compliance
- Airport emissions gathered from EPA National Emission Inventory program
- Ultra Fine Particulate studies

Air Quality Standards

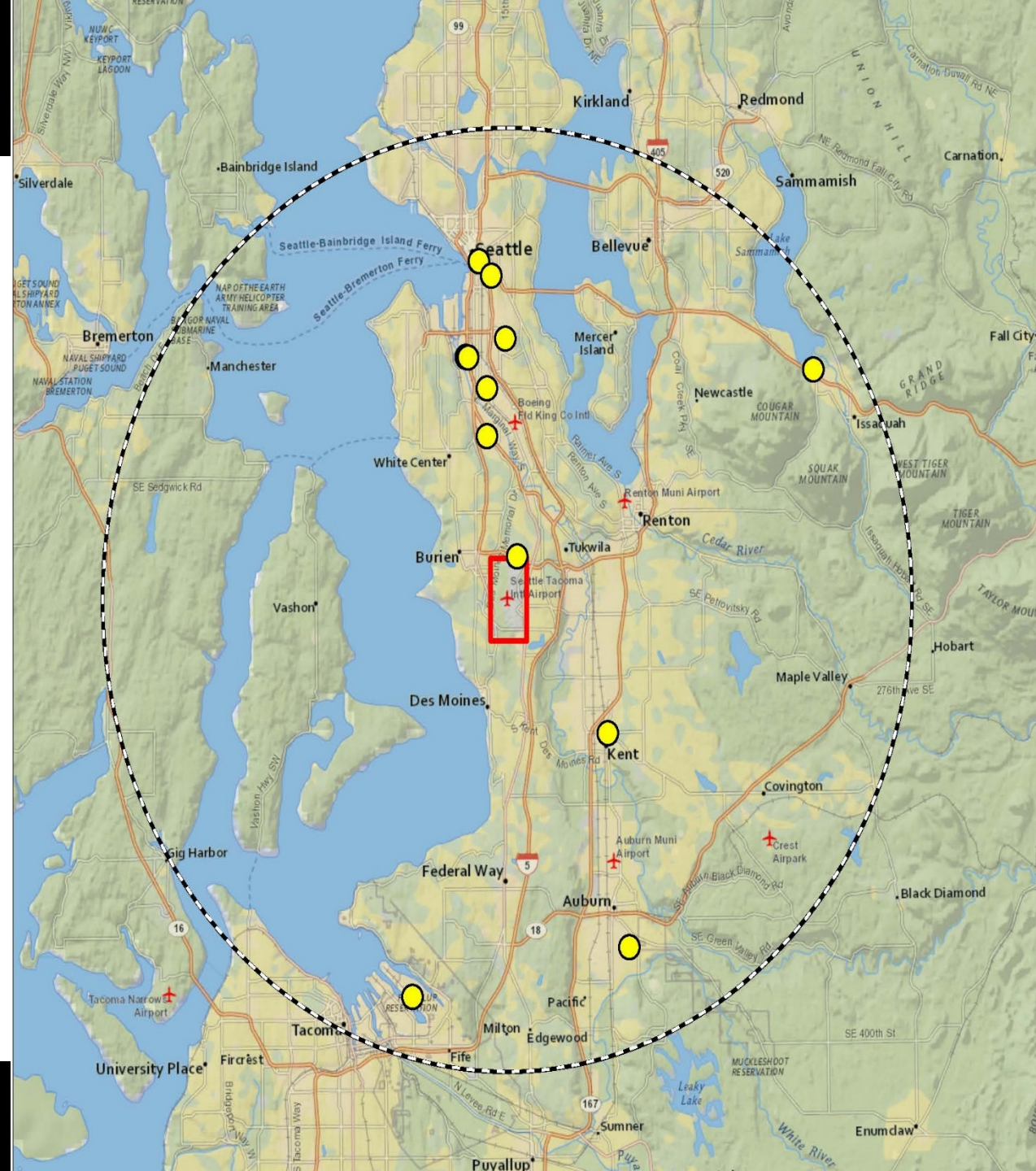
Pollutant	Standards	Change from 1997
Carbon Monoxide 8-hr Average 1-hr Average	9 ppm 35 ppm	None
Particulate Matter (PM₁₀) 24-hr Average	150 µg/m ³	Annual standard revoked
Particulate Matter (PM_{2.5}) Annual 24-hr average	12 µg/m ³ 35 µg/m ³	Current more stringent
Nitrogen Dioxide Annual 1-hr average	0.053 ppm 0.1 ppm	1 hour added

Air Quality Standards

Pollutant	Standards	Change from 1997
Ozone 8-hr Average	0.07 ppm	1-hr removed; current 8-hr more stringent
Sulfur Dioxide 3-hr Average 1-hr Average	0.05 ppm 75 ppm	Annual and 24- hr removed; 1- hr more stringent
Lead Calendar Quarter Average	0.15 $\mu\text{g}/\text{m}^3$	Current 10 times more stringent

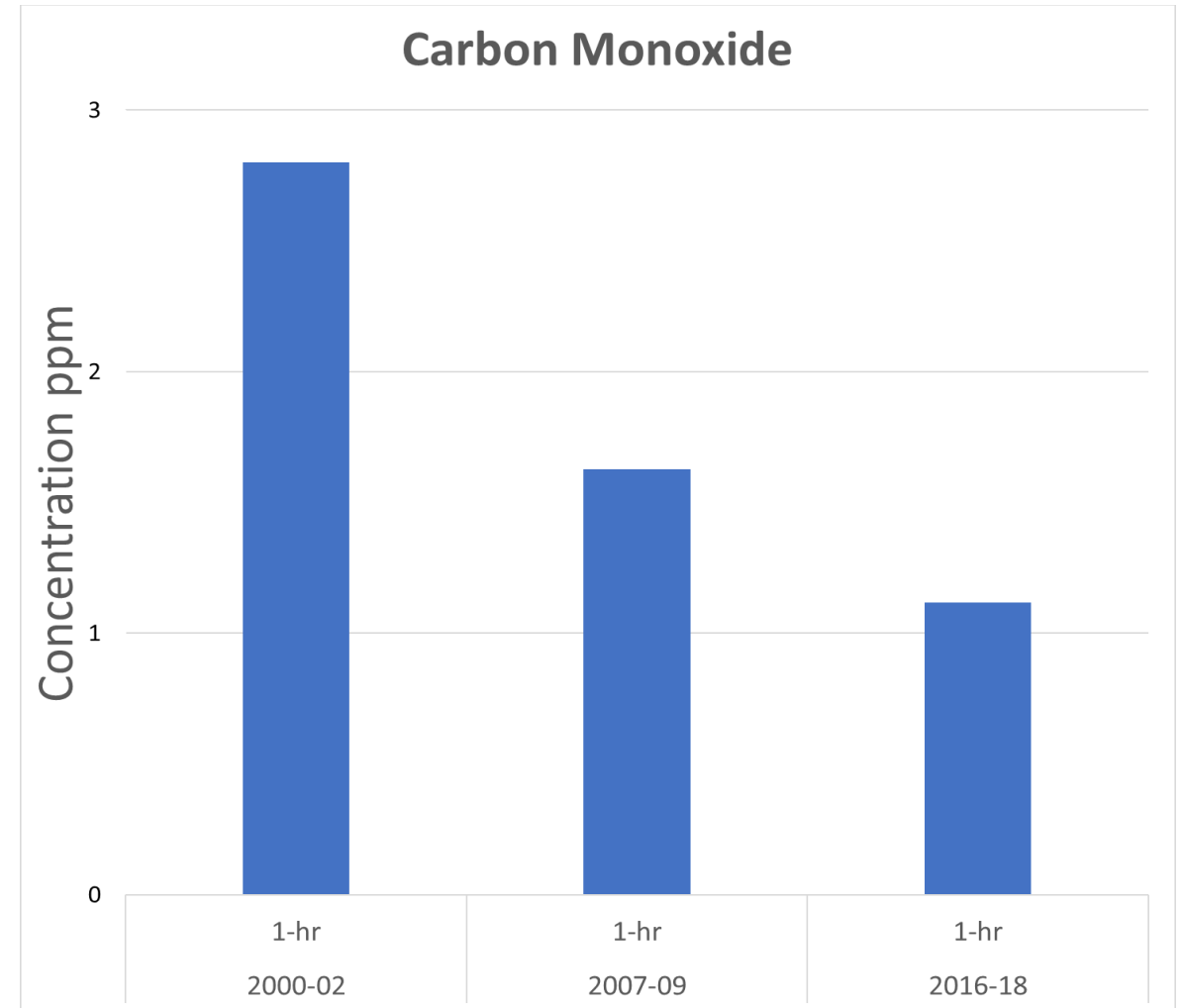
Air Quality – Monitoring Data

- All EPA/Dept. of Ecology sites
- 10-mile radius surrounding Sea-Tac Airport



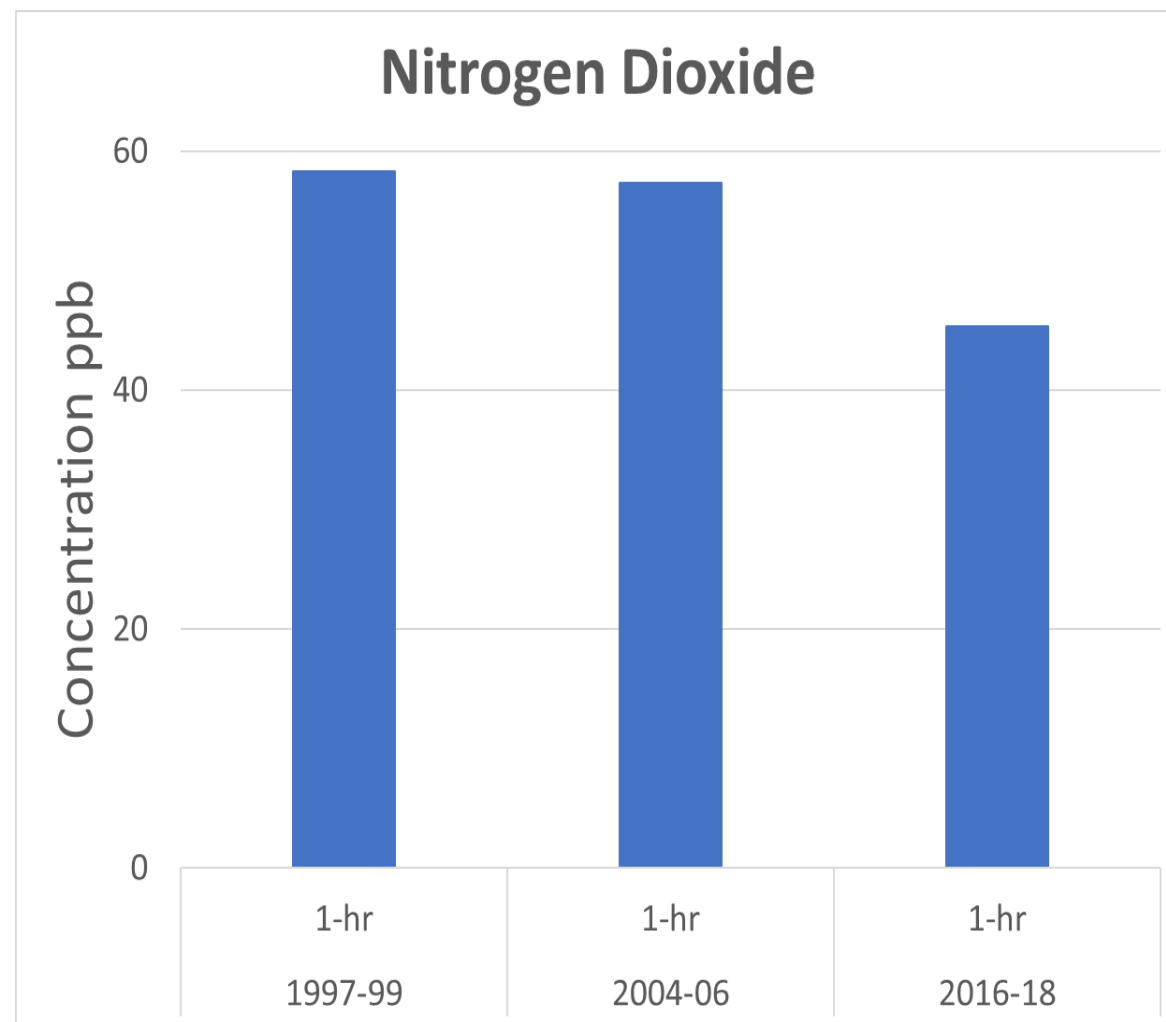
Air Quality – Monitoring Data

- CO standard: 1-hr – 35 ppm



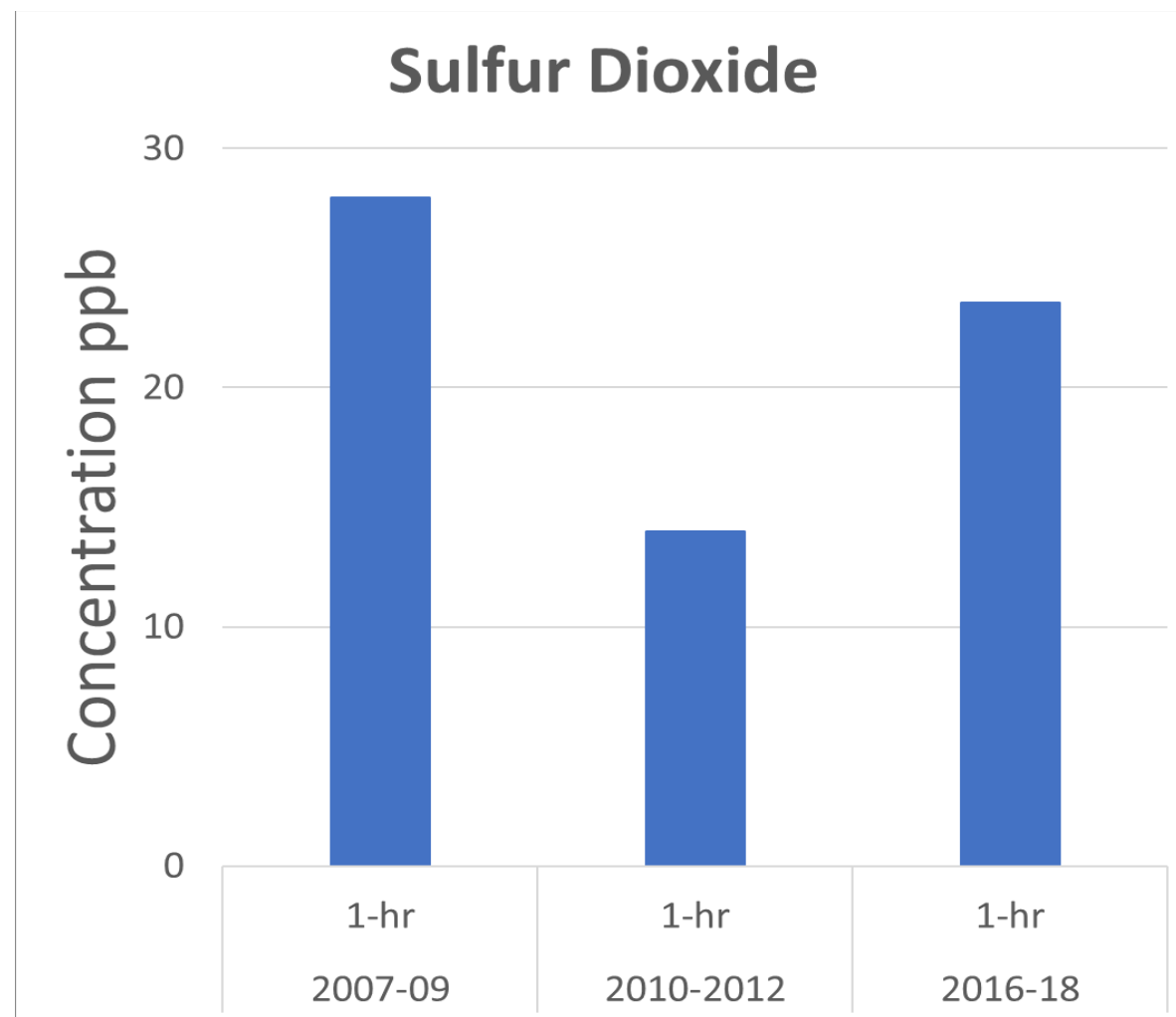
Air Quality – Monitoring Data

- NO₂ standard: 1-hr – 100 ppb



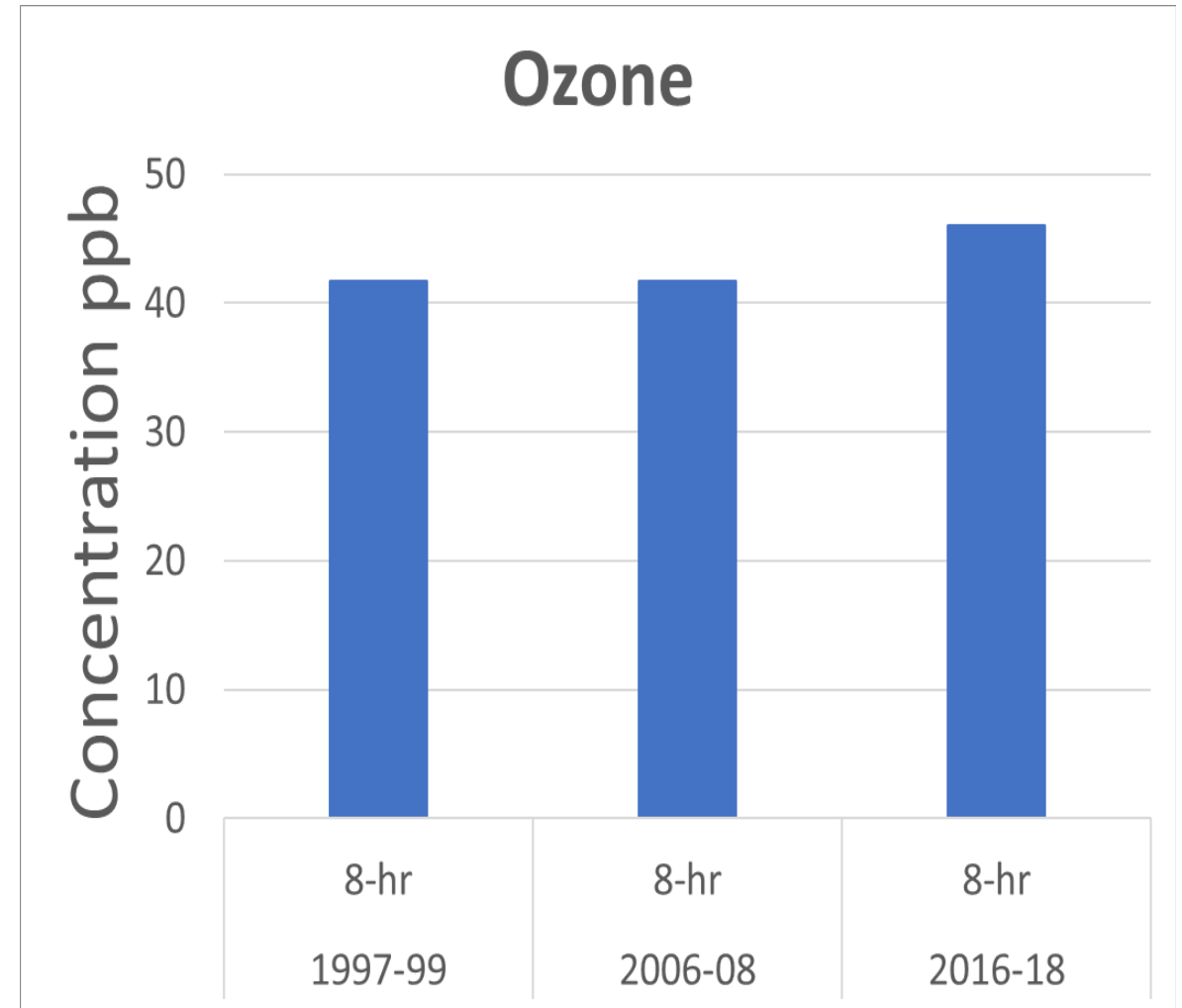
Air Quality – Monitoring Data

- SO₂ standard: 1-hr – 75 ppb



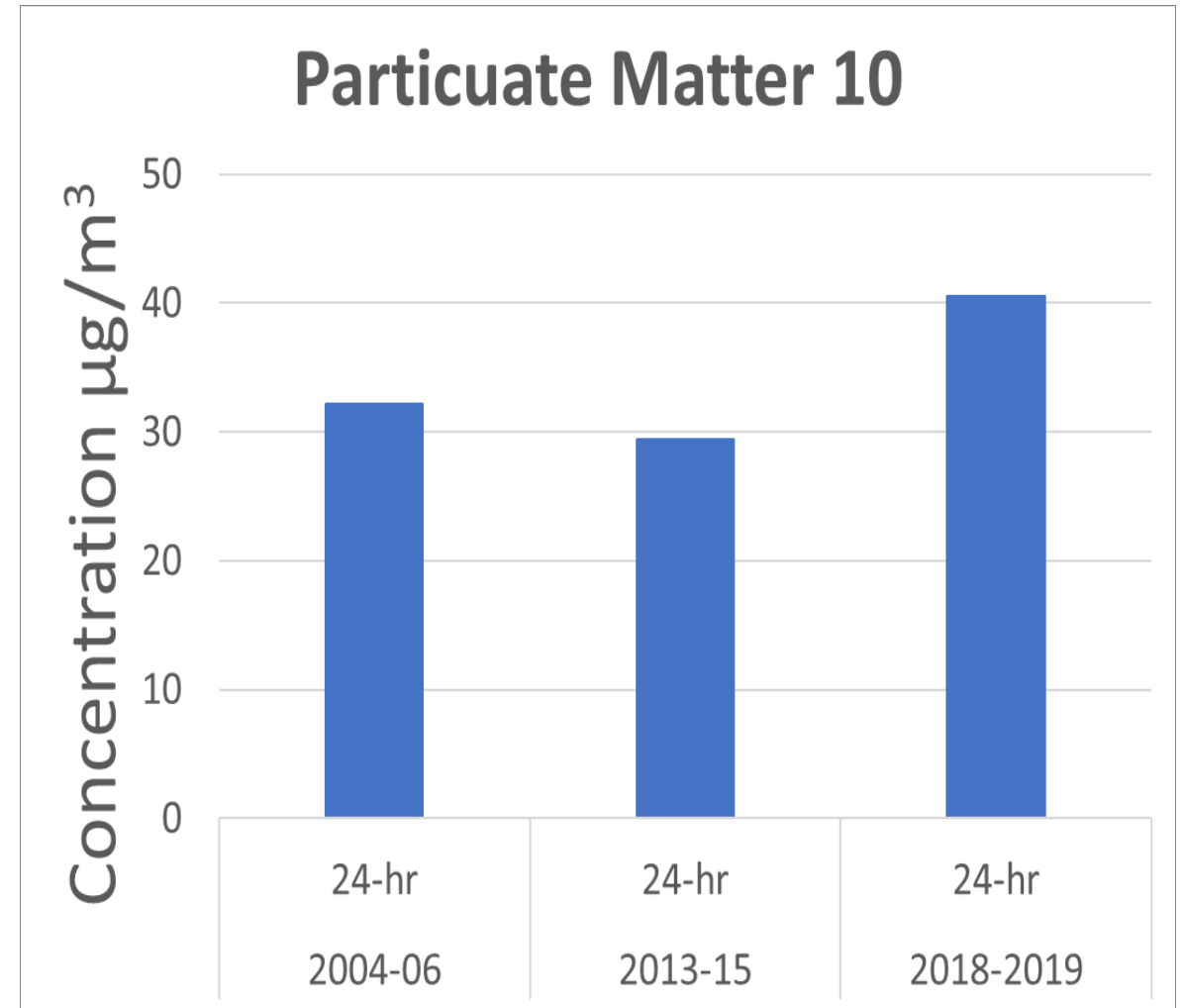
Air Quality – Monitoring Data

- O₃ standard: 8-hr – 70 ppb



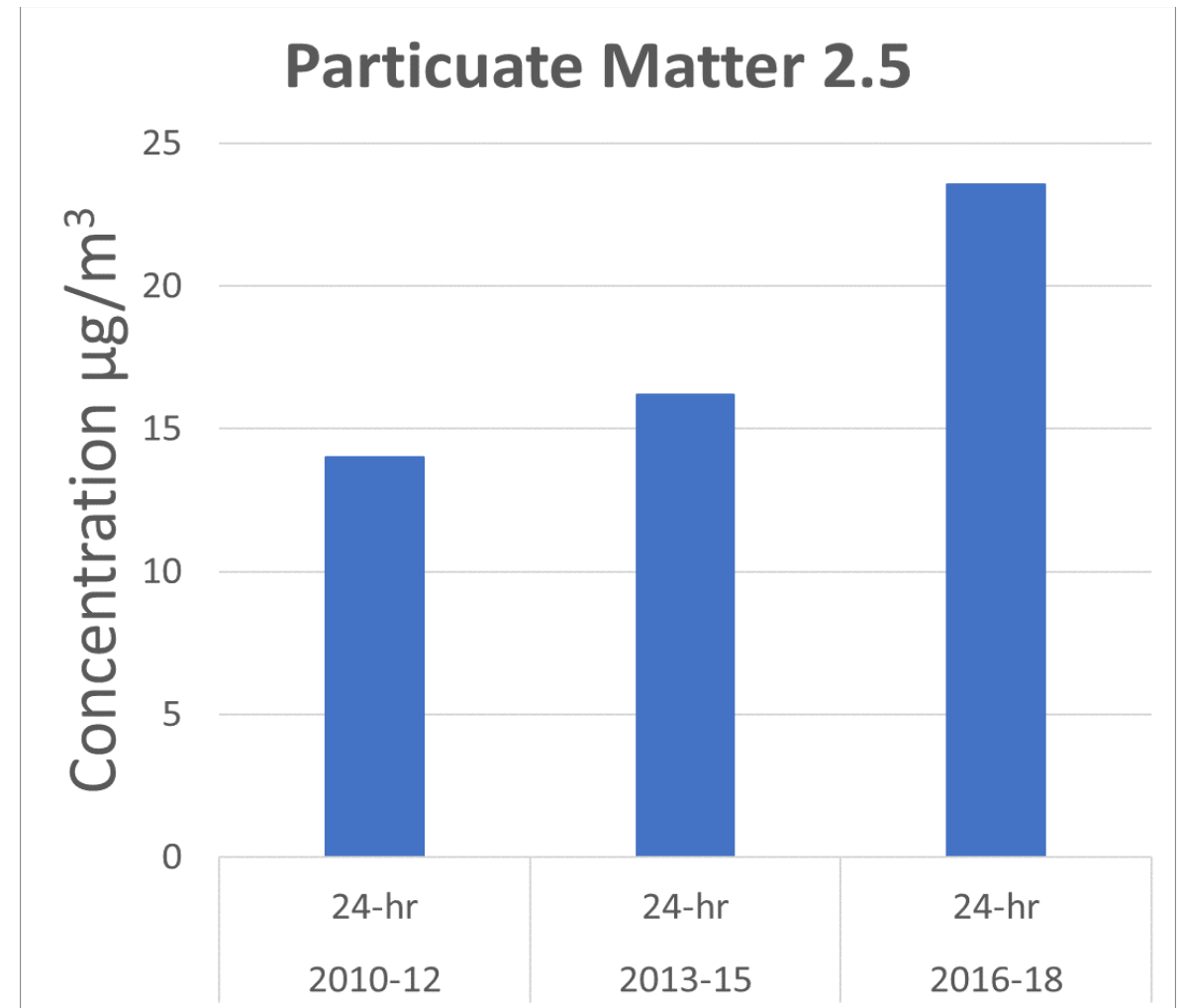
Air Quality – Monitoring Data

- PM₁₀ standard: 24-hr – 150 µg/m³



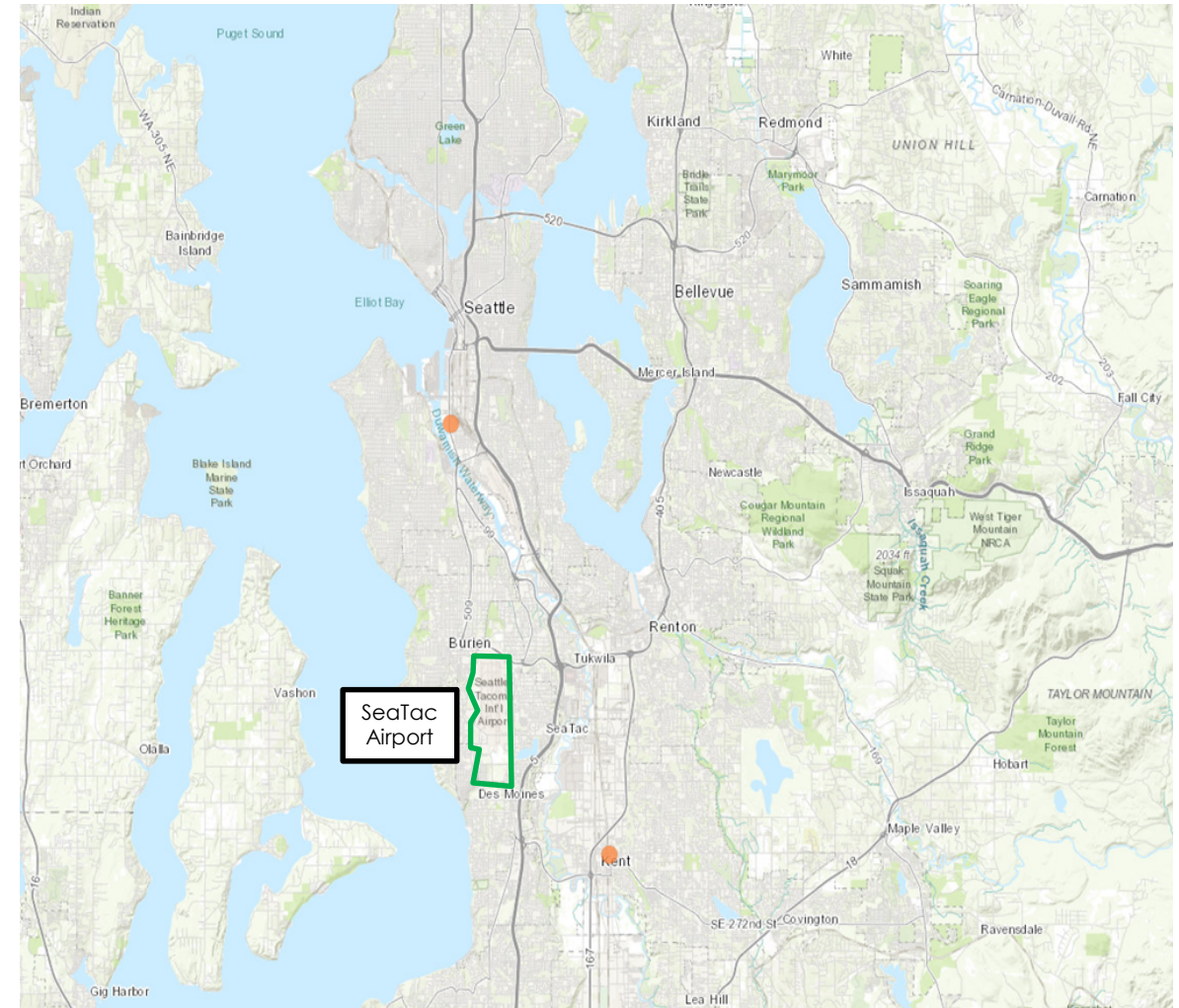
Air Quality – Monitoring Data

- PM_{2.5} standard: 24-hr – 35 µg/m³



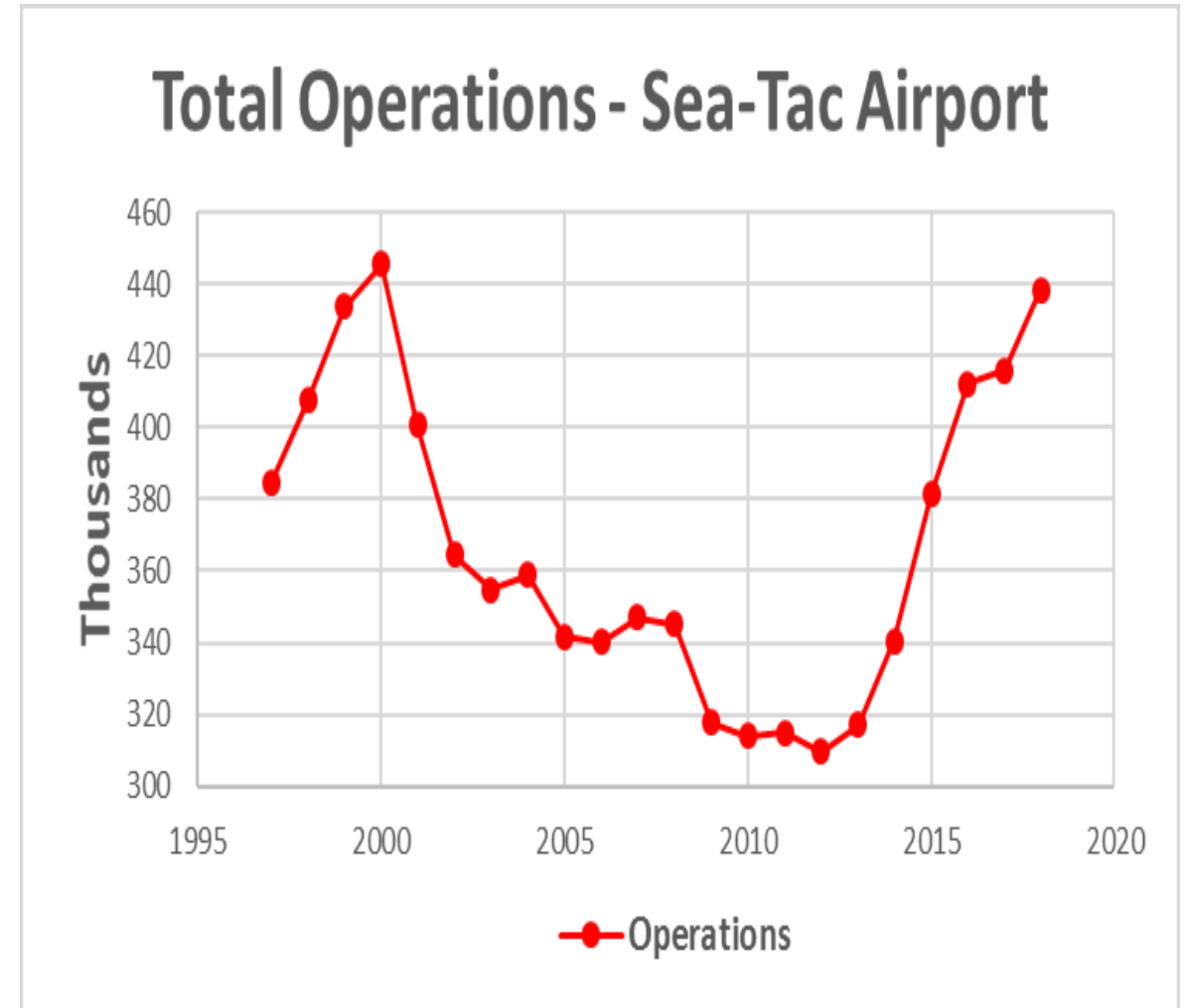
Air Quality – Monitoring Data

- Areas of Concern – PM_{2.5}
 - Still meet the standard



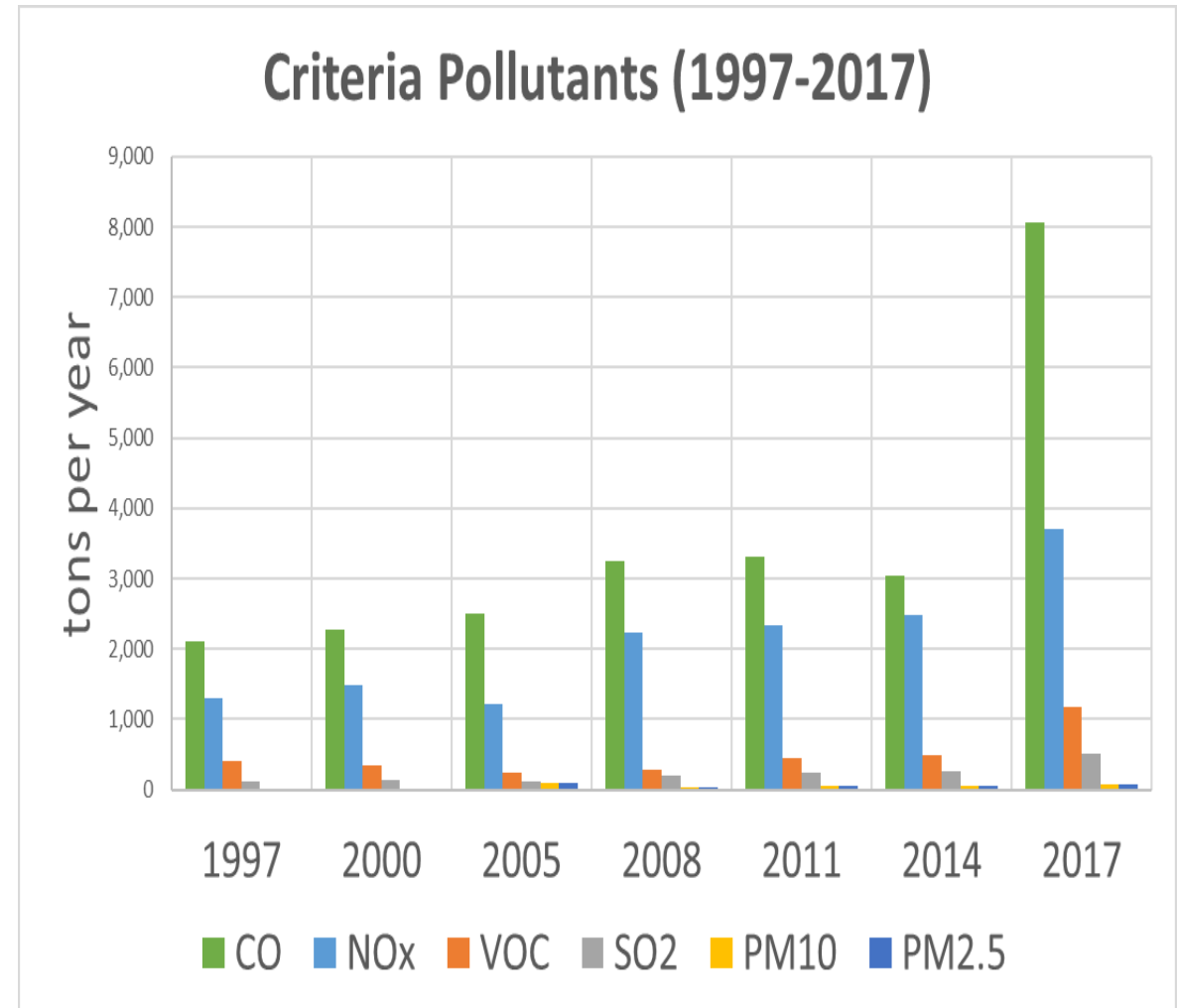
Air Quality – Airport Operations

- Operations consist of
 - Air Carrier
 - Air Taxi
 - General Aviation
 - Military
 - Local



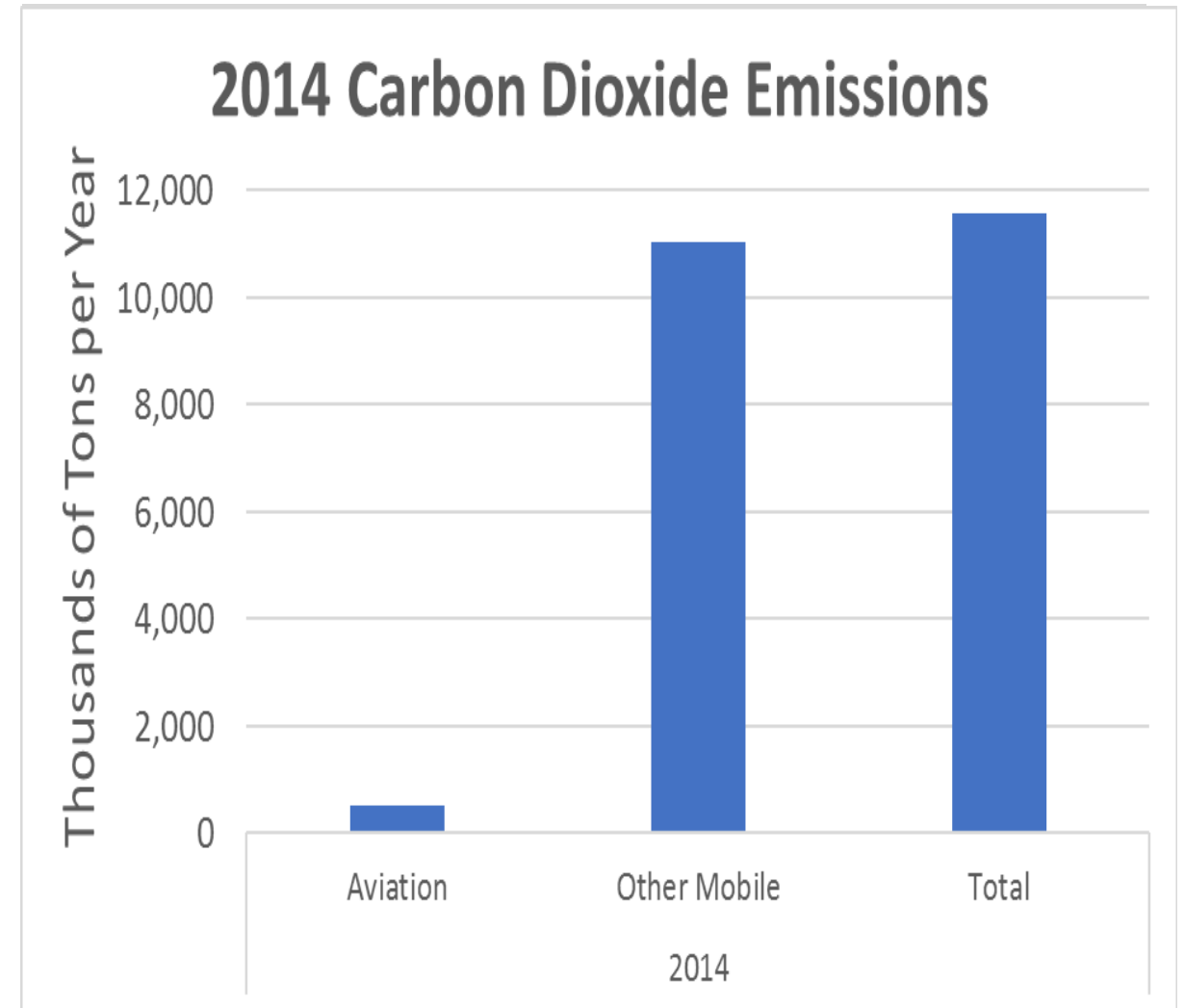
Air Quality – Criteria Pollutants for Sea-Tac

- 2017
 - Large increase of CO, SO₂ and VOC
 - Gradual increase of NOx and particulate emissions



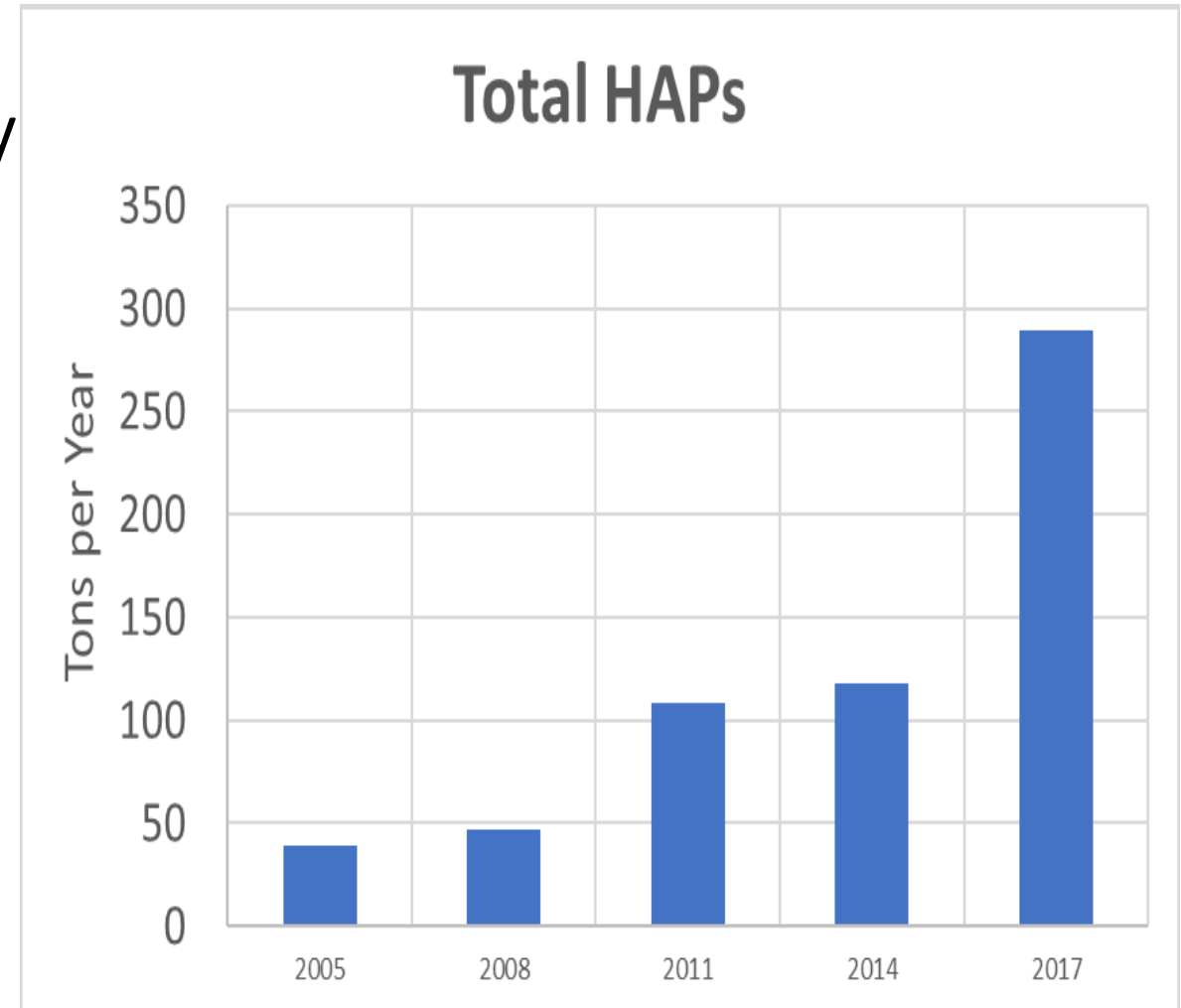
Air Quality – Carbon Dioxide from Sea-Tac & Other Mobile Sources

- Total Aviation Emissions
 - 2014 – 525,357 tons
- Sea-Tac % of Total King County Mobile Sources Emissions
 - 2014 – 4 - 5%
- 2017 Sea-Tac Emissions
 - County mobile source not yet available



Air Quality – Hazardous Air Pollutants for Sea-Tac

- 2003 Puget Sound Agency Study
 - Concerns: Mobile volatile organics, diesel particulate matter, and woodsmoke
- 2017 Puget Sound Data
 - Monitors: downward trend



Air Quality – Ultra-fine Particulate

Characteristic	UFP	PM _{2.5/10}
US Air Standards?	No; none proposed	Yes
Size	0.1 micrometer (µm) = 100 nanometers	2.5/10 µm
Measurement Units	Particle/cubic centimeter (#/cc)	µg/m ³
Health Effects	Uncertain compared to PM _{2.5}	Penetrate lungs
Monitoring	Technology not ready per Puget Sound 2017 Study	Federal Reference Method

Air Quality – Ultra-fine Particulate Studies

Study	Year	Highlights
UW	Current	<ul style="list-style-type: none">• Airport and vehicles studied• Jet aircraft emit ultra-ultra fine (< 30 nm)• Handheld and stationary particle counters
LAX	2018	<ul style="list-style-type: none">• Studies small number asthmatic adults• Suggests higher inflammation in lungs and blood circulation
Boston	2018	<ul style="list-style-type: none">• Suggested correlation of particle numbers associated with landing/take-off• Nothing conclusive; recommends more study

Air Quality – Ultra-fine Particulate Studies

Study	Year	Highlights
Bay Area Air Quality Management District	Updated 2016	<ul style="list-style-type: none">• UFP for all sources surrounding the bay area• 0.021 ton per day UFP airport vs. 5.8 ton per day all sources (Winter 2015)
Santa Monica Airport	2010	<ul style="list-style-type: none">• Aircraft idling → large UFP numbers• Take off short term spikes up to 2,000 times background
UW/USC	2016	<ul style="list-style-type: none">• UFP in LAX and Atlanta under the airport flight path• Concentrations under flight paths elevated

Air Quality

- Air quality standards change over time
- Regional monitoring data shows compliance
- Airport emissions gathered from EPA National Emission Inventory program
- Ultra Fine Particulate studies

Analysis Metric:

NOISE & VIBRATION

Presenter:

Gary Maynard, AICP
Senior Planner

Common Noise Sources and Measurement

Sound Levels Produced by Common Noise Sources

Thresholds/Noise Sources	Sound Level (dBA)	Subjective Evaluations	Possible Effects on Humans
Human Threshold of Pain Carrier jet takeoff at 50 ft	140	Deafening	Continuous exposure to levels above 70 can cause hearing loss in majority of population
Siren at 100 ft Loud rock band	130		
Jet takeoff at 200 ft Auto horn at 3 ft	120		
Chain saw Noisy snowmobile	110		
Lawn mower at 3 ft Noisy motorcycle at 50 ft	100	Very Loud	Speech Interference
Heavy truck at 50 ft, maximum	90		
Pneumatic drill at 50 ft Busy urban street, daytime	80	Loud	Sleep Interference
Normal automobile at 50 mph Vacuum cleaner at 3 ft	70		
Air conditioning unit at 20 ft Conversation at 3 ft	60	Moderate	
Quiet residential area Light auto traffic at 100 ft	50	Faint	
Library/Quiet home	40		
Soft whisper at 15 ft	30	Very Faint	
Slight rustling of leaves	20		
Broadcasting Studio	10		
Threshold of Human Hearing	3		

← Jet Noise



Components of Sound

1. Level (amplitude)
2. Pitch (frequency)
3. Duration (time pattern)

Sound Energy is Measured in Decibels (dB)

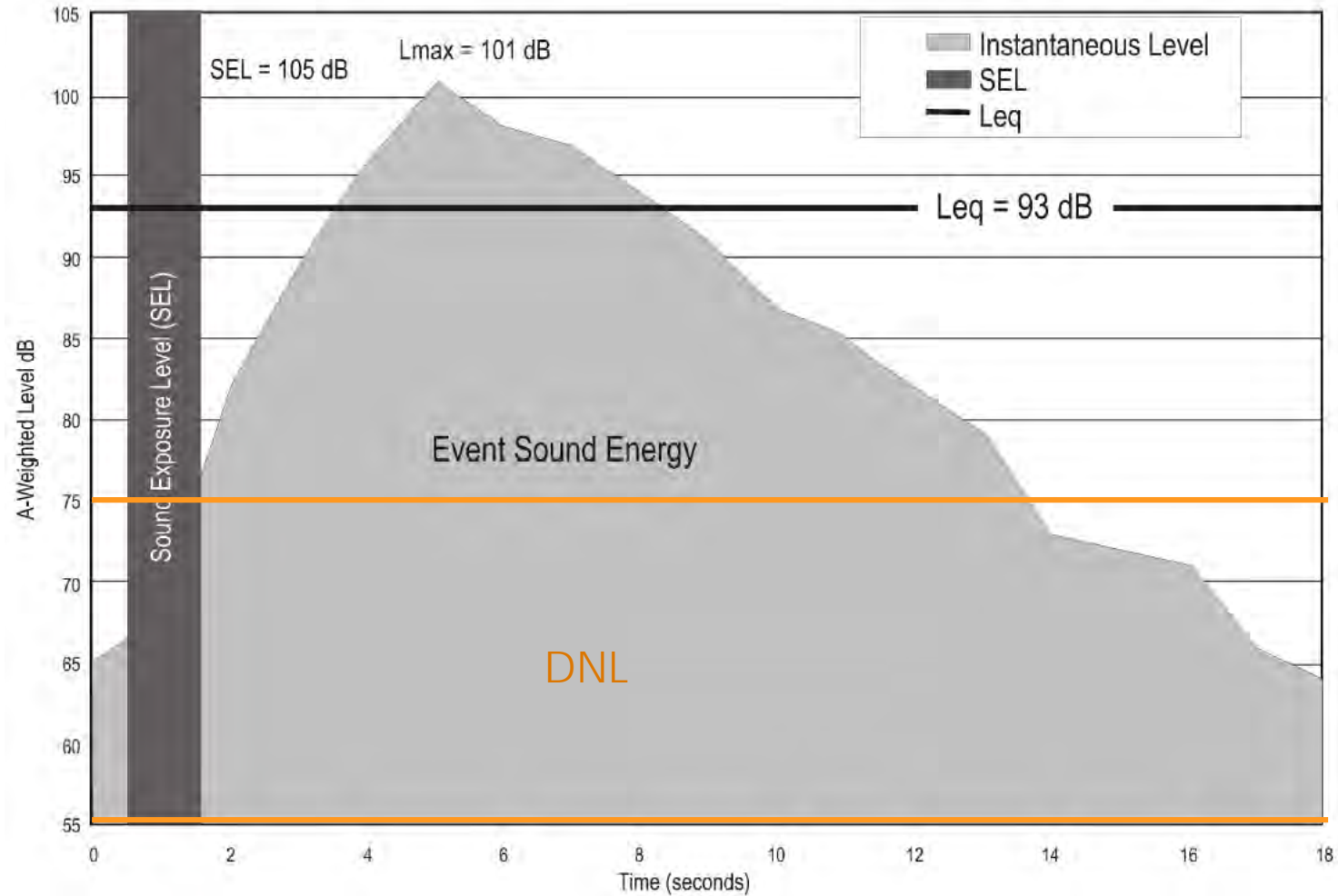
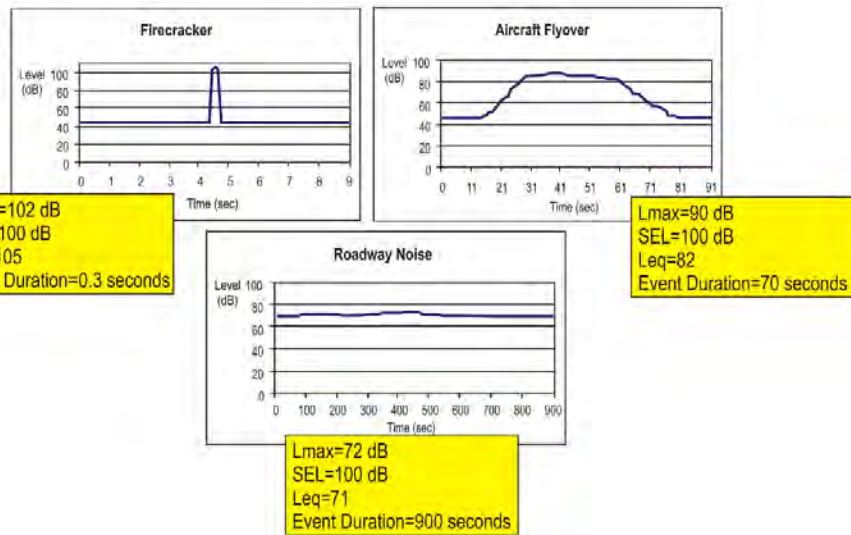
Due to the Way Human Ear Hears Sounds a Logarithmic Scale is Used (A-weighted - dBA) thus a 10 dB Increase Equals a Tenfold Increase in Sound Energy

Important Sound Metrics for Aviation

**SEL – Total Sound Energy from Single Source

LEQ – Average Sound Energy

**DNL – 24-Hour Average Sound Energy with 10 dB Added at Night



Sources of Airport/Aircraft Noise

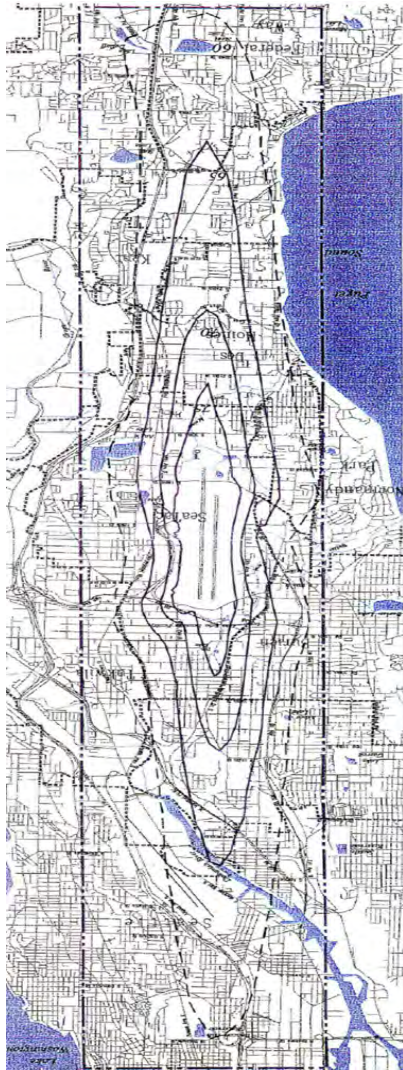
- Ground Vehicles
- Aircraft Runups
- Aircraft Taxiing
- Arriving Aircraft
- Departing Aircraft
- Aircraft Overflights

Most Complaints

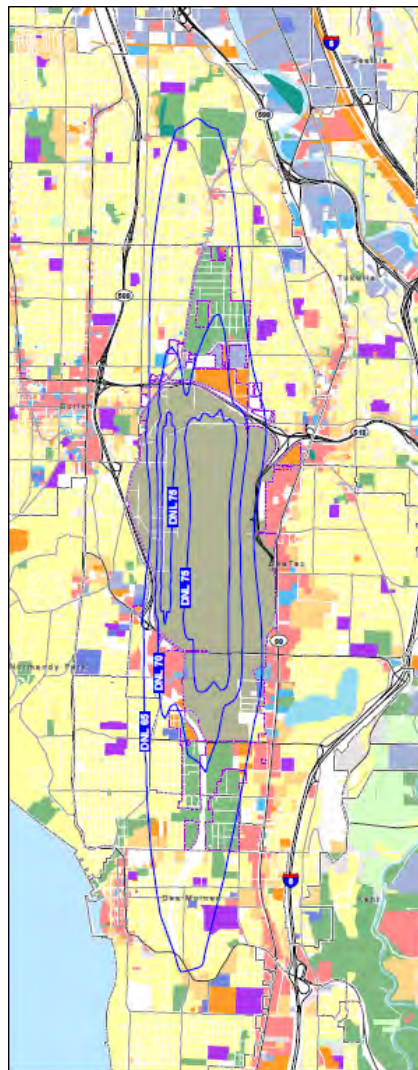


FAA NOISE CONTOURS OVER TIME

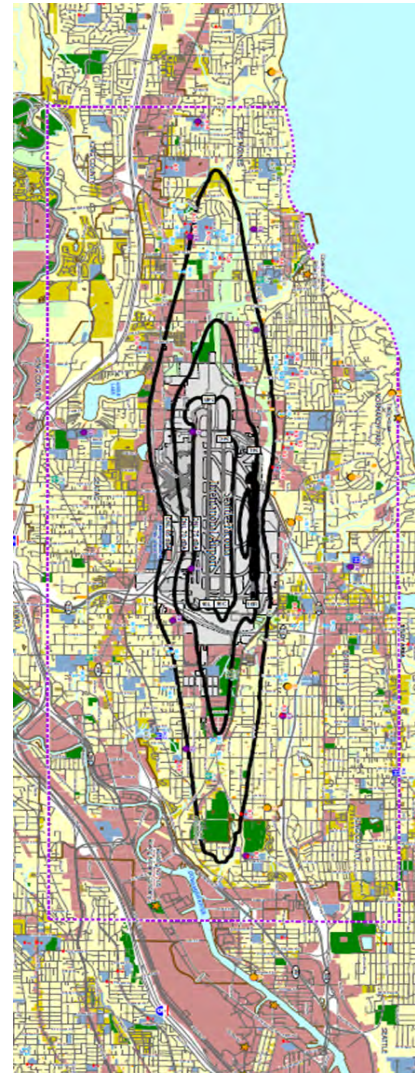
1994



2010



2018



FAA Remedy Area > 65 DNL

1994 Area Affected within 65 DNL Contour – 12.23 square miles

2018 Area Affected within 65 DNL Contour – 7.3 square miles

1994 65 DNL and Greater Contour

- People – 31,800
- Residences – 13,620

2016 65 DNL and Greater Contour

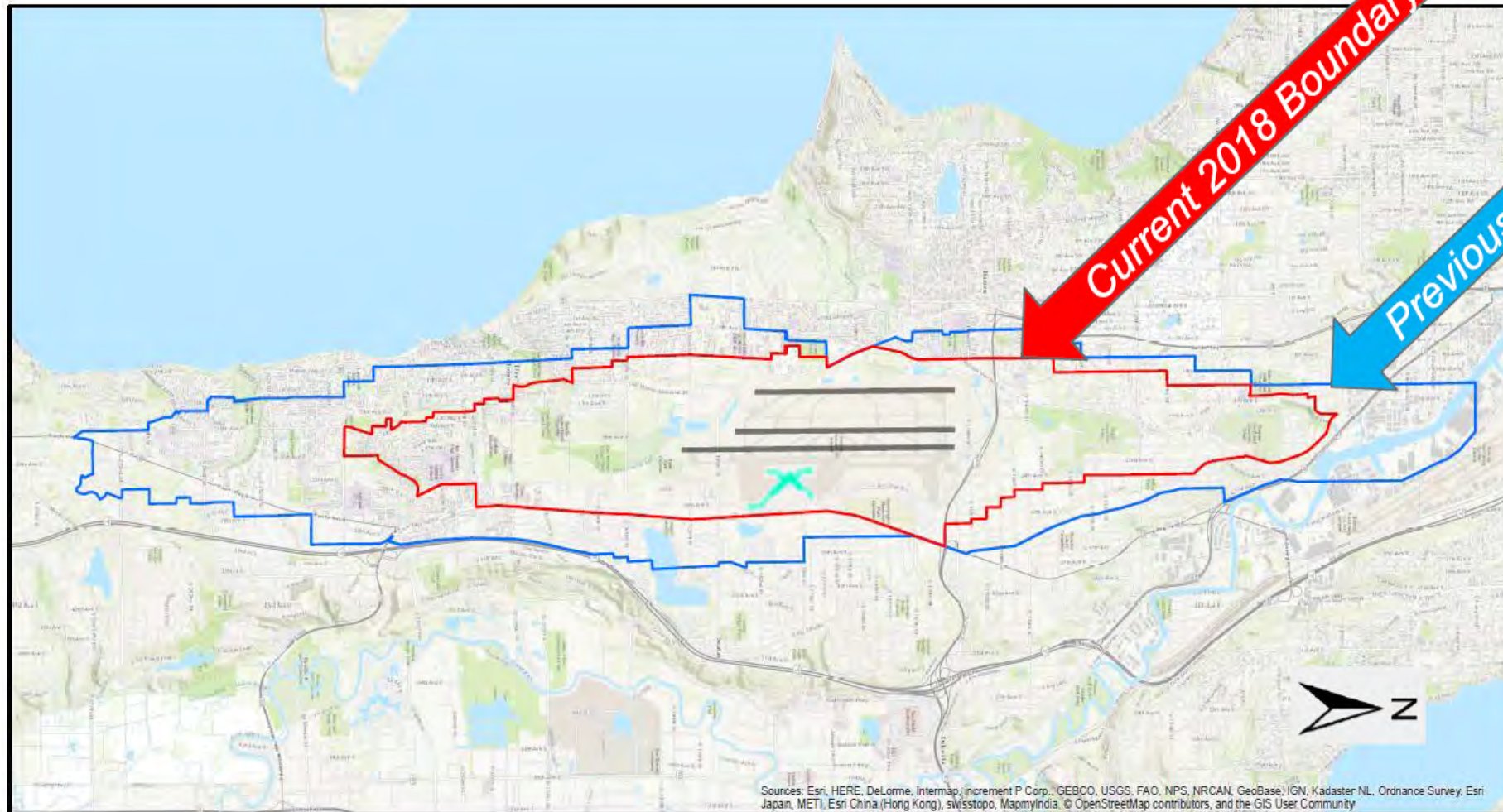
- People – 11,389
- Residences – 4,394

Trend

65 DNL Contour contracted 1.5 miles on the north end and 2.5 miles on the south end from 1994 to 2018 – largely due to phasing out older – louder aircraft

FAA NOISE CONTOURS

SEA-TAC NOISE REMEDY BOUNDARY



Largely Due to Phasing Out Older, Louder Aircraft

Past Noise Mitigation

Areas Within the 65 DNL Contour
are Eligible for Sound Mitigation

Sound Insulation

- 9,400 Homes
- 8 Highline Schools
- 5 Condominium Complexes (246 units)
- 14 Buildings on the Highline College Campus

Acquisition

- 5 Mobile Home Parks
- 69 Homes North of 3rd Runway
- 1,400 Single Family Homes - Some for 3rd Runway Itself



Ongoing and Future Noise Mitigation

Ongoing Mitigation (Sound Insulation)

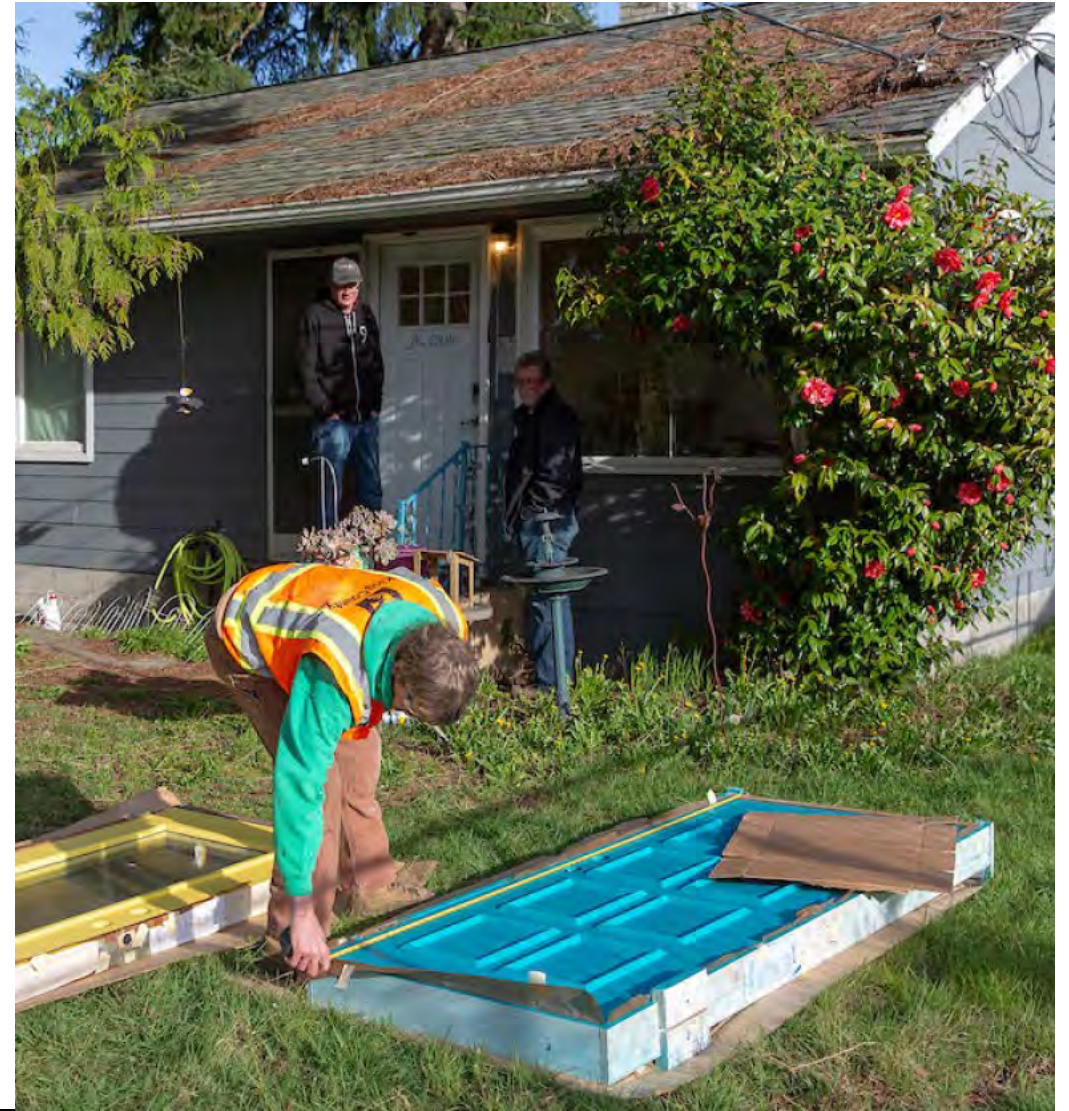
- 135 Homes
- 3 Condominium Complexes/133 Units
- 18 Apartment Buildings
- 7 Church Structures
- 7 Schools (includes new school under construction)

Voluntary Acquisitions (South of 3rd Runway)

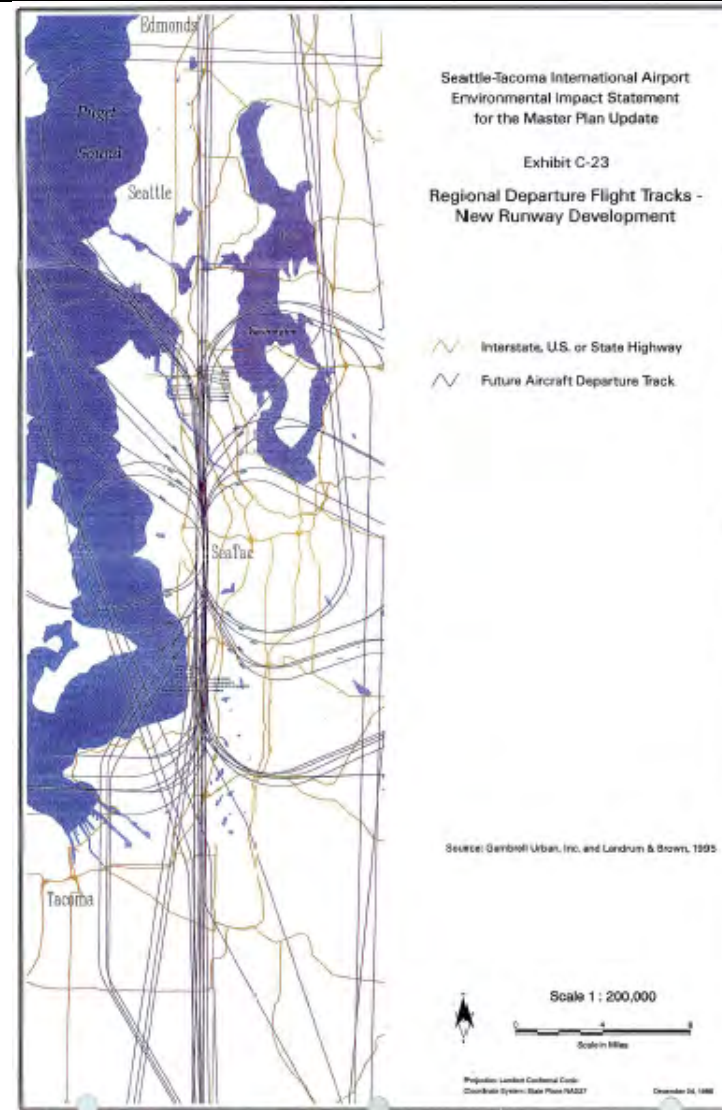
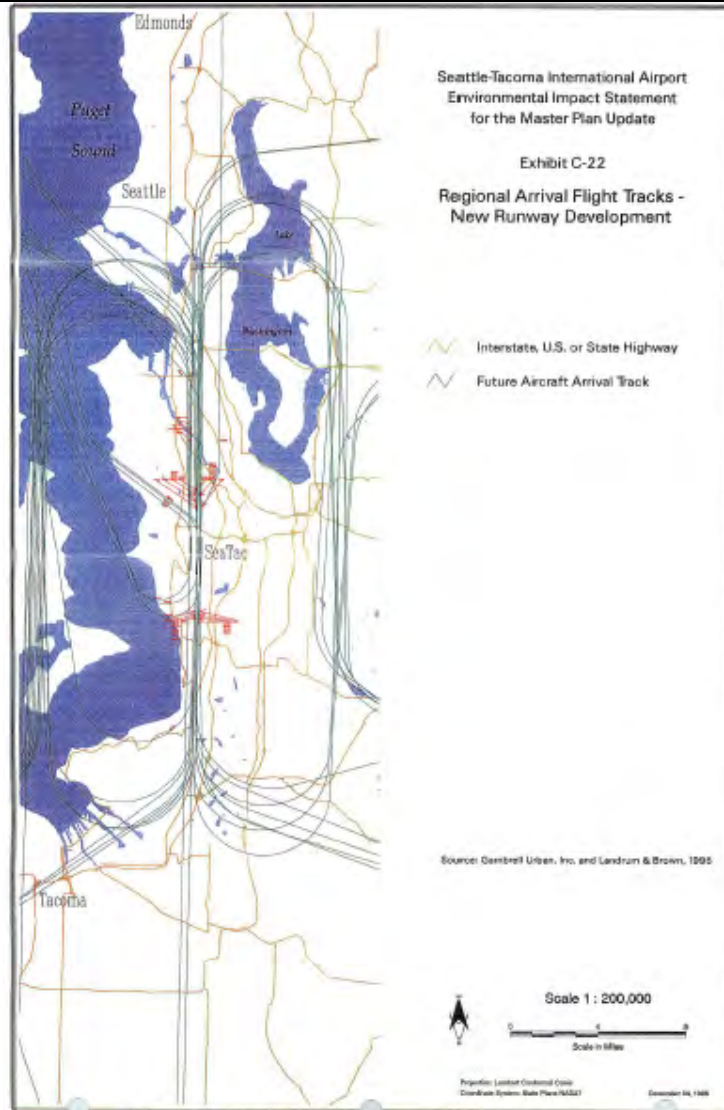
- 16 Single-Family Homes
- 6 Apartment Buildings

Schools

- 7 Highline Schools
- Des Moines Elementary (under construction)



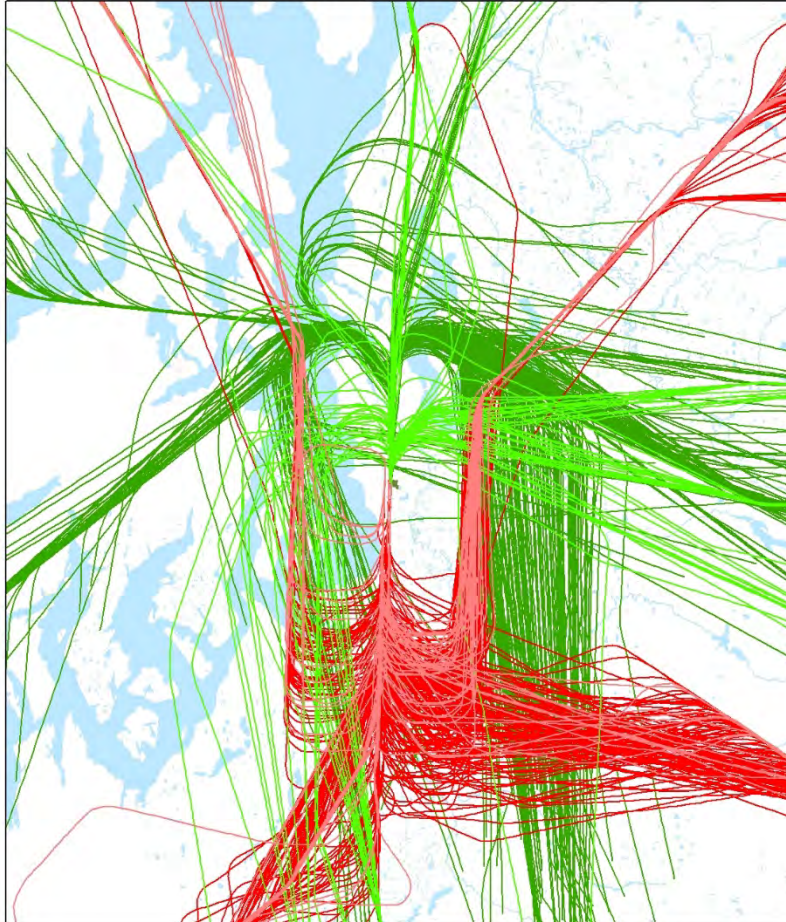
Flight Patterns Trends - 1995



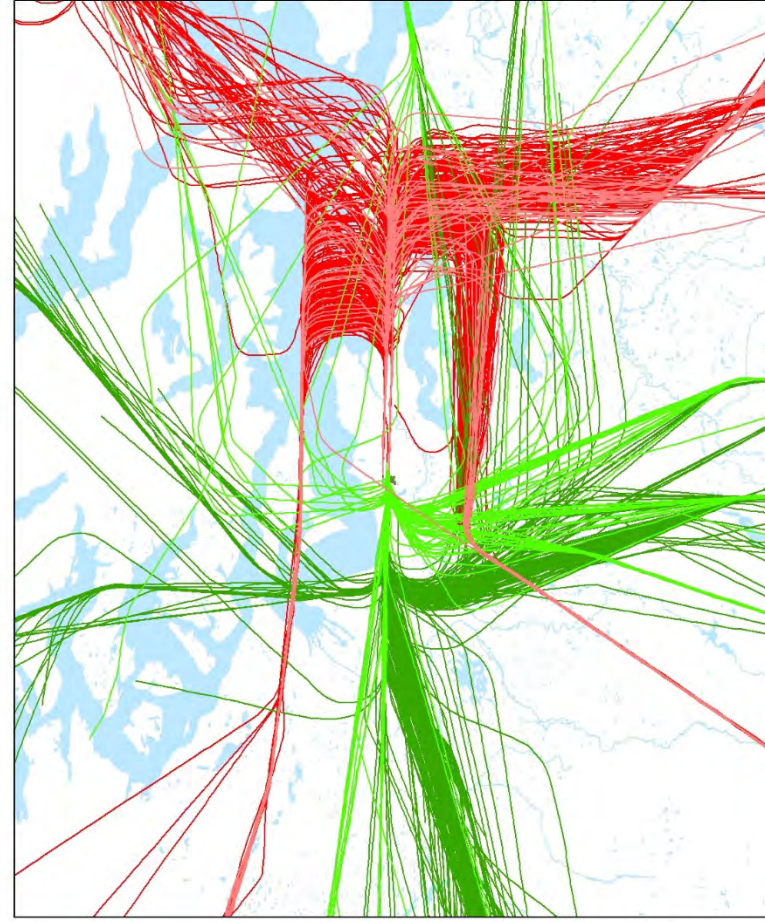
Flight Tracks
Fairly Uniform

Flight Patterns Trends - 2018

Seattle- Tacoma International Airport
North Flow Sample Flight Track Map



Seattle- Tacoma International Airport
South Flow Sample Flight Track Map



Trend

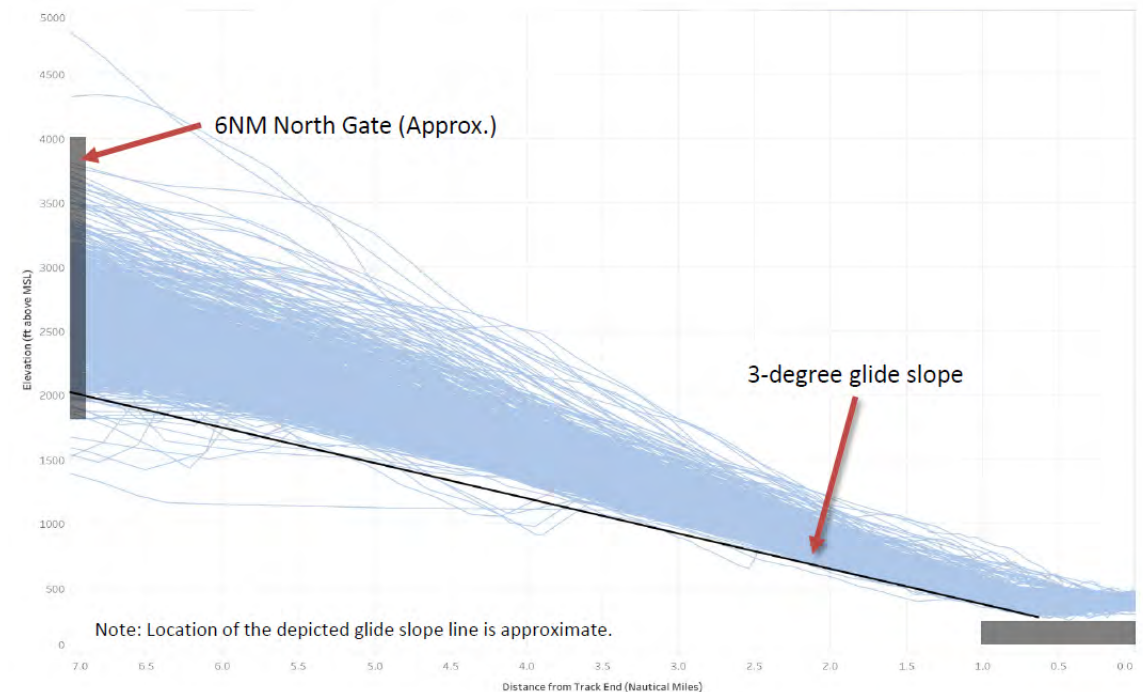
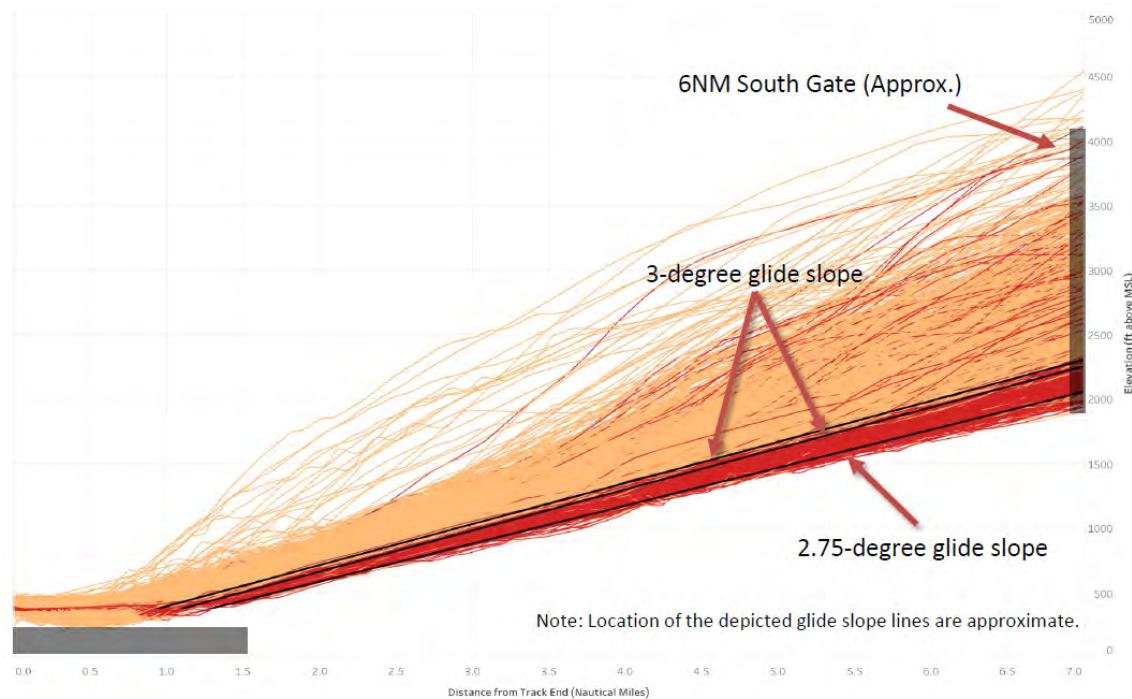
More diverse flight paths due to NextGen changes to flight paths and increased flights from other locations such as Asia (93 International Non-Stop Destinations)

Aircraft Arrival Altitudes Effects on Noise

FAA Requirement at SeaTac - 2.75 Glide Slope on Runway 34R
Increasing Glide Slope Would Reduce Overflight Noise

North Flow Arrivals July 2017

South Flow Arrivals July 2017



Airport Operations

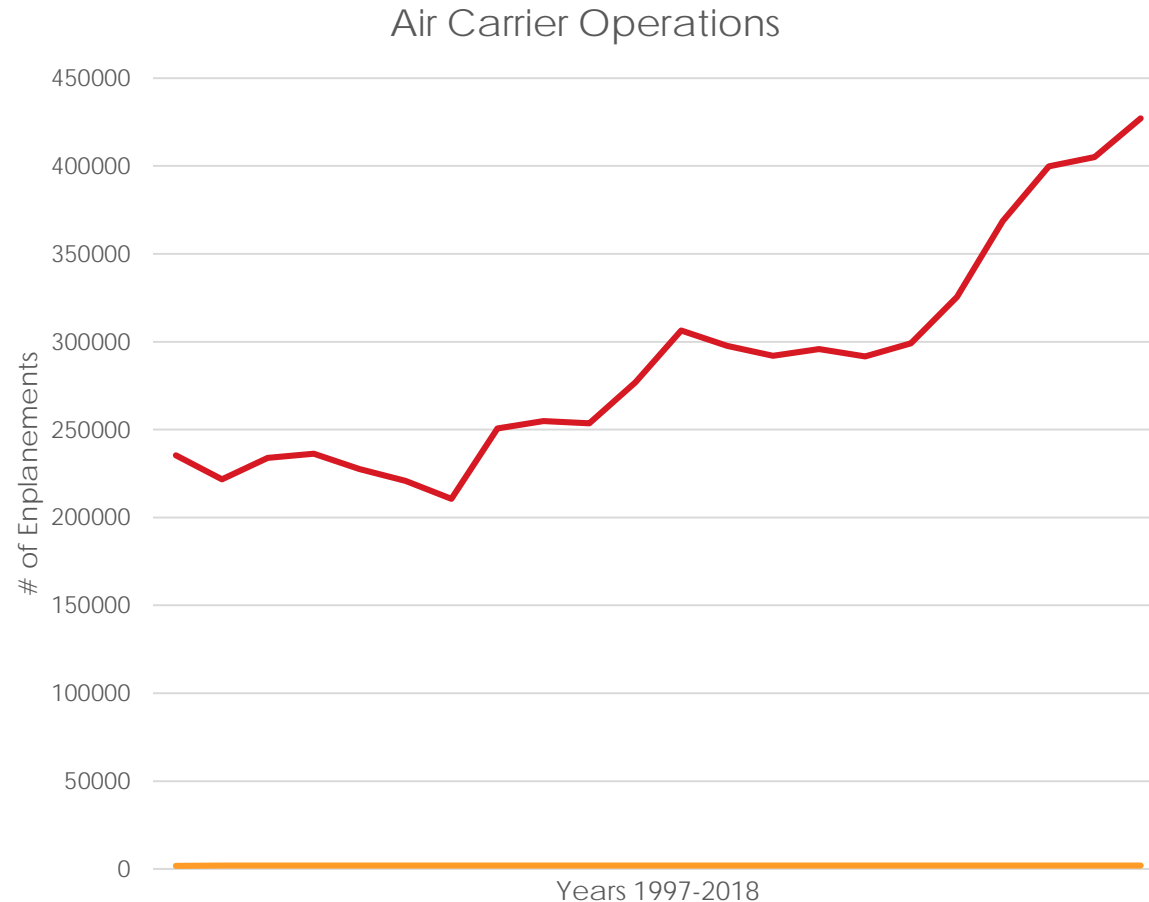
Trends
General
Aviation and
Air Taxi
Decreasing
Operations
Over Time –
Air Carrier
Increasing
Operations
Over Time

Calendar Year Facility	Air Carrier	Itinerant				Local			Total Operations	
		Air Taxi	General Aviation	Military	Total	Civil	Military	Total		
1997 SEA	Trend	235,445	143,034	5,820	80	384,379	103	0	103	384,482
1998 SEA		221,705	180,563	5,183	126	407,577	20	0	20	407,597
1999 SEA		233,914	194,352	5,321	59	433,646	14	0	14	433,660
2000 SEA		236,355	203,723	5,448	95	445,621	56	0	56	445,677
2001 SEA		227,589	168,322	4,668	66	400,645	16	9	25	400,670
2002 SEA		220,733	139,793	4,073	59	364,658	13	0	13	364,671
2003 SEA		210,603	140,777	3,336	54	354,770	49	0	49	354,819
2004 SEA		250,605	105,377	2,685	121	358,788	103	3	106	358,894
2005 SEA		254,829	83,928	2,654	59	341,470	284	8	292	341,762
2006 SEA		253,507	82,147	3,675	95	339,424	621	13	634	340,058
2007 SEA		276,954	64,745	3,587	80	345,366	883	11	894	347,046
2008 SEA		306,425	34,453	2,111	60	343,049	0	0	0	345,057
2009 SEA		297,621	17,133	3,046	73	317,873	0	0	0	317,873
2010 SEA		292,016	18,562	3,262	114	313,954	0	0	0	313,954
2011 SEA		295,763	15,324	3,708	149	314,944	0	0	0	314,944
2012 SEA		291,664	14,196	3,604	133	309,597	0	0	0	309,597
2013 SEA		299,156	14,440	3,510	80	317,186	0	0	0	317,186
2014 SEA		325,425	10,813	4,113	127	340,478	0	0	0	340,478
2015 SEA		368,722	8,401	4,160	125	381,408	0	0	0	381,408
2016 SEA		399,742	9,513	2,802	93	412,150	20	0	20	412,170
2017 SEA		405,049	8,651	2,338	86	416,124	12	0	12	416,136
2018 SEA	Increasing	427,170	8,509	2,625	87	438,391	0	0	0	438,391
2019 SEA		295,967	3,075	1,647	53	300,742	0	0	0	300,742
Sub-Total for SEA		6,626,959	1,669,831	83,376	2,074	8,382,240	2,194	44	2,238	8,387,272
Total:		6,626,959	1,669,831	83,376	2,074	8,382,240	2,194	44	2,238	8,387,272

Source: Air Traffic Activity System

Air Carrier Operations

Year	Air Carrier
1997	235,445
1998	221,705
1999	233,914
2000	236,355
2001	227,589
2002	220,733
2003	210,603
2004	250,605
2005	254,829
2006	253,507
2007	276,954
2008	306,425
2009	297,621
2010	292,016
2011	295,763
2012	291,664
2013	299,156
2014	325,425
2015	368,722
2016	399,742
2017	405,049
2018	427,170



Increase in Operations and Resulting **SEL** Events

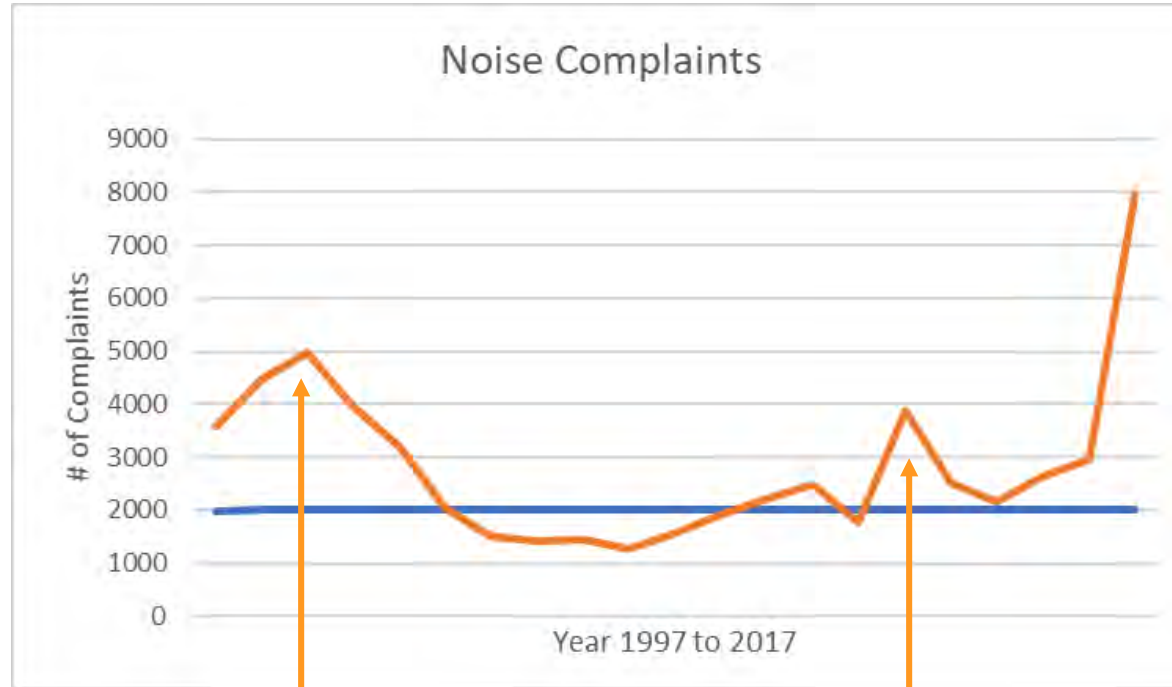
1997-2009 – 26% increase
 2009-2018 – 44% increase
 1997-2018 – 81% increase

2013 to 2018

- Difference of 128,014 Operations and SEL Events/Year
- 350 More Operations and SEL Events/Day

Yearly Noise Complaints

Year	Calls into Noise Office
1997	3,571
1998	4,482
1999	4,968
2000	3,941
2001	3,192
2002	2,050
2003	1,493
2004	1,432
2005	1,442
2006	1,274
2007	1,556
2008	1,927
2009	2,231
2010	2,488
2011	1,786
2012	3,868
2013	2,507
2014	2,172
2015	2,632
2016	2,959
2017	7,929
2018	170,000

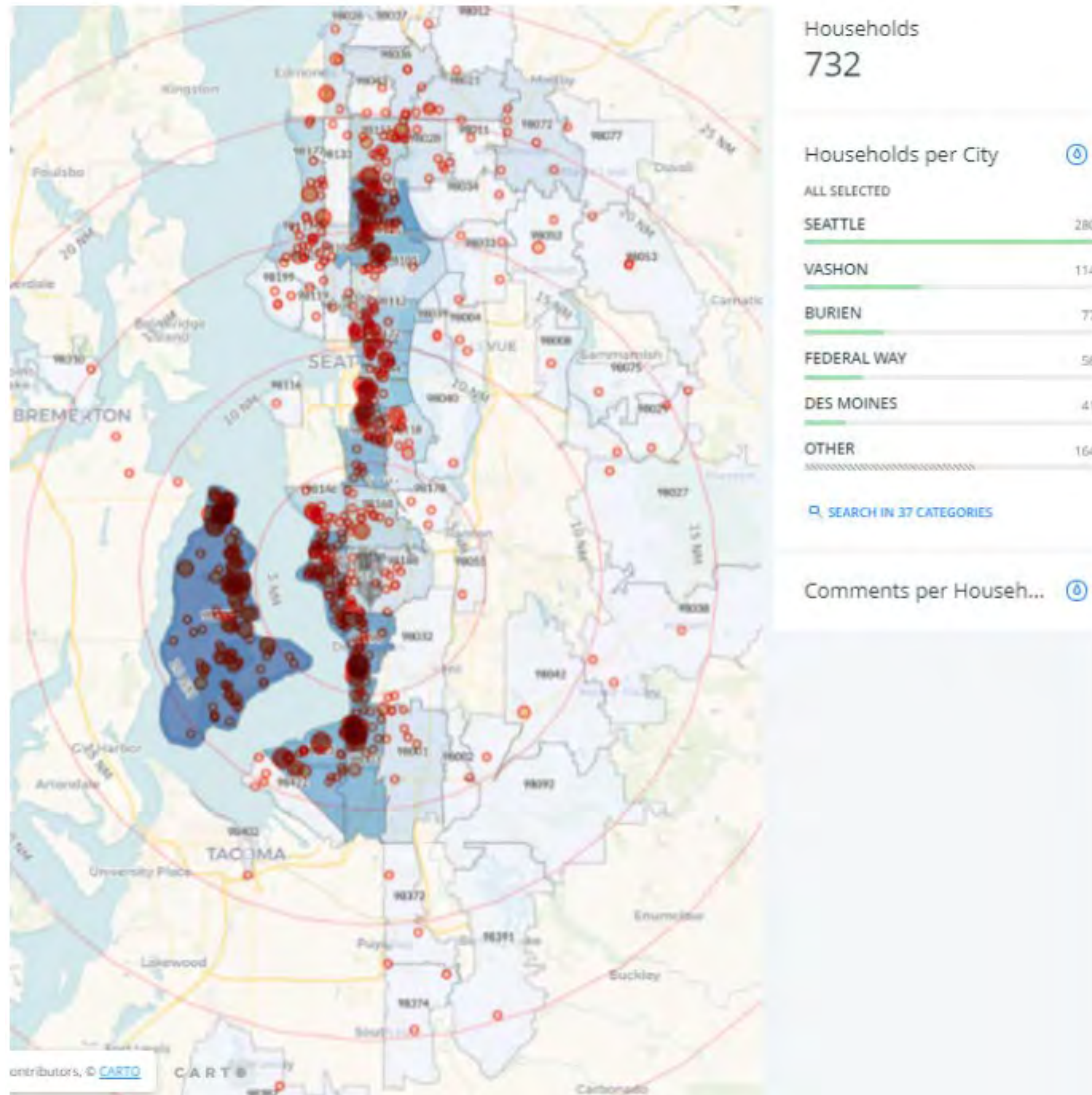


1999
 1997-2000 Air Taxi Increased 43% and Peaked at 203,723 Ops, Gen Aviation peaked

2009
 Third Runway Open

2018 170,000 complaints
 NextGen Changes Flight Tracks and Noise App

Recent 2019 Noise Complaints Three Months



732 Households
110,600 Complaints
July – September 2019

2019 Projected Complaints – 400,000+

Most Noise Complaints Due to SEL
Events During Aircraft Overflights and
Night Operations

Trend
As Operations Continue to Increase and
Flight Paths Change Noise Complaints
Have Increased

Noise Induced Vibration

- No FAA Regulations Concerning Noise Induced Vibration
- Vibration is Caused by Low Frequency Aircraft Noise (LFN)
 - LFN – frequencies in the range of 20-80 HZ
 - LFN – less absorption in air so persists for longer distances
 - LFN – transmits through structures greater than at higher frequencies
- Effects of Low Frequency Aircraft Noise
 - Perceptible Transmissions Through Structure
 - Building Vibration (Window, Wall and Floor Vibration)
 - Audible Rattling of Objects (Pictures)
 - Human Health Effects – Annoyance

TREND – Increased Operations will Continue to Generate SEL Event Vibration

Health Effects of Noise

- Cardiovascular
- Metabolic Effects
- Sleep Disturbance
- Cognitive Impairment/Children's Learning
- Birth Outcomes
- Hearing Impairment
- Speech Disturbance
- Mental Health/Quality of Life
- Annoyance



SeaTac Noise Programs

■ Part 150 Noise Program Goals

Reduce Noise Levels Where Feasible; Implement Noise Mitigation Measures; Reduce Noise Sensitive Uses Near Airport; Be Consistent with Local Land Uses Where Feasible

- Voluntary Effort Reducing Late Night Flights with Carriers
- Wing Vents on A320 Create Whistling Noise-Vortex Generator
- Fly Quiet Program Aimed at Carriers
- Sea-Tac Stakeholder Advisory Round Table (START)
 - Consideration of Glide Slope Adjustment
 - Ground Noise Analysis
 - Noise Abatement Departure Study



Any Changes in Flight Procedures Proposed for Noise Abatement Requires Approval by FAA for its effects on Flight Safety, Efficient Use of Airspace, Security and National Defense, Management and Control of National Airspace and Traffic Control Systems, and Compliance with Applicable Laws.

Final Message - Noise



- Noise is the Number One Issue Affecting Residences, Businesses, Schools, and Other Facilities Located Near SeaTac Airport and In the Greater Puget Sound Region
- Noise Is a Difficult Issue to Address Due To:
 - The Number of Air Carriers Operating Different Aircraft
 - State of Aircraft Design – Inherent Noise Given Off by Jet Engines
 - Outdoor Activities Necessary to Operate an Airport
- The Overall Trend in the Short-Term is Likely to be Steady or Increasing Noise Levels

Analysis Metric:

MOBILITY

Presenter:

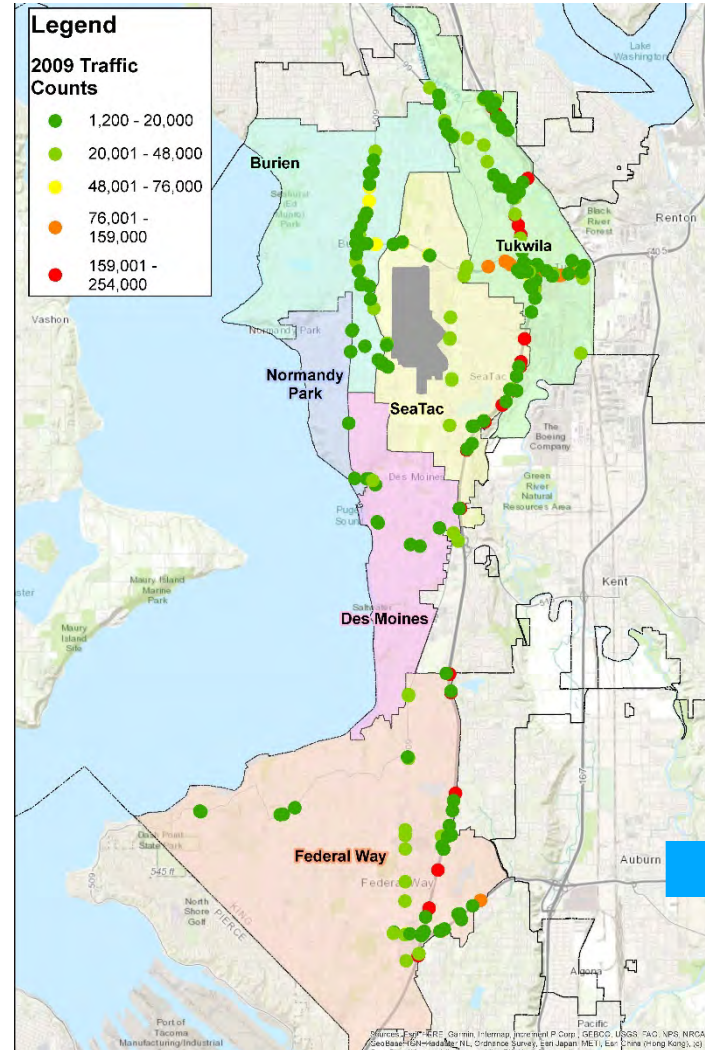
Ryan Givens, AICP
Senior Planner



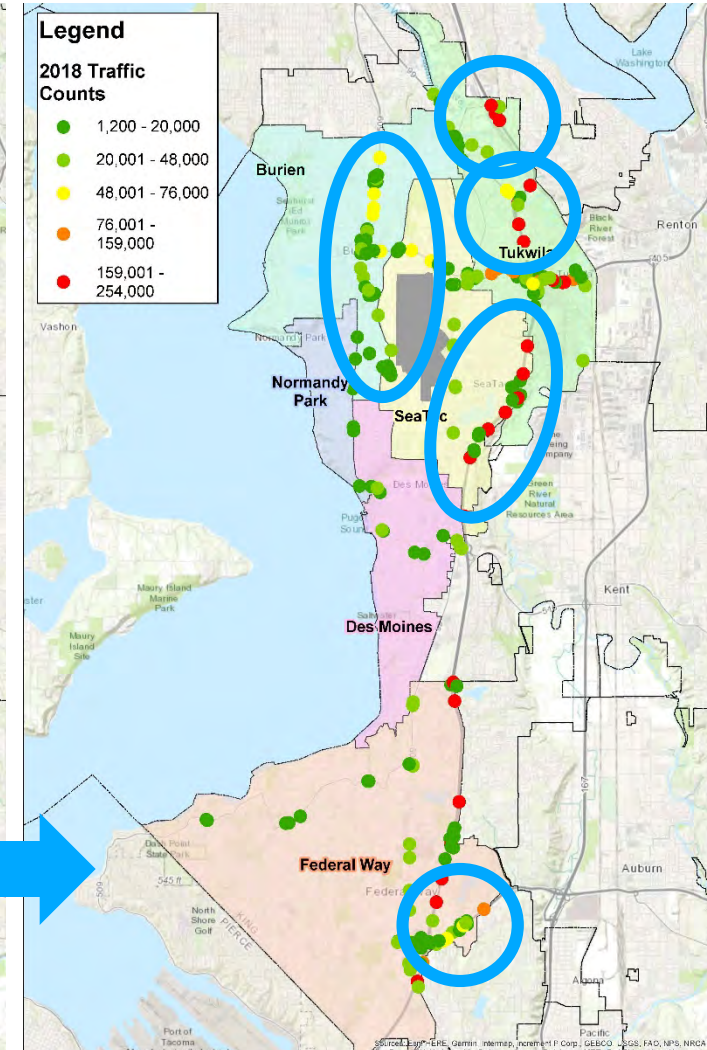
Major Arterials – Traffic Counts

- Annual Average Daily Traffic
 - Source: 2018 & 2009 WSDOT Traffic Geoportal (TGP Traffic Counts)
 - All directions of travel
- Areas of congestion
 - Burien – Rte 509 adjacent to airport
 - I-5 towards I-405 interchange
 - I-5 along Sea-Tact & Des Moines
 - I-5 & Rte 18

2009



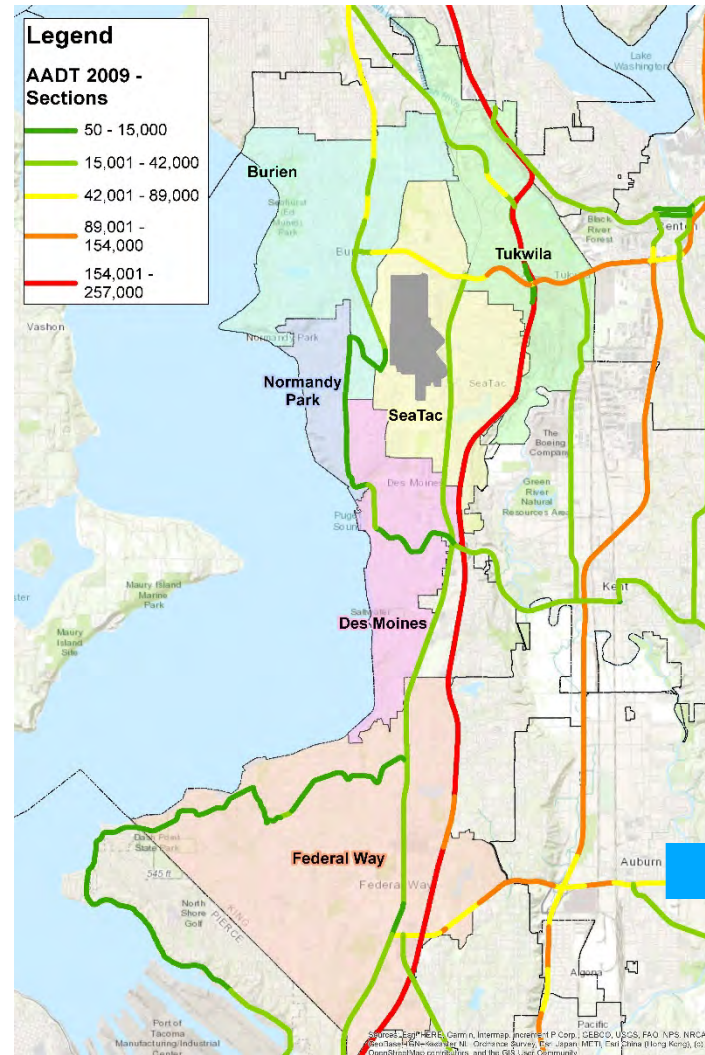
2018



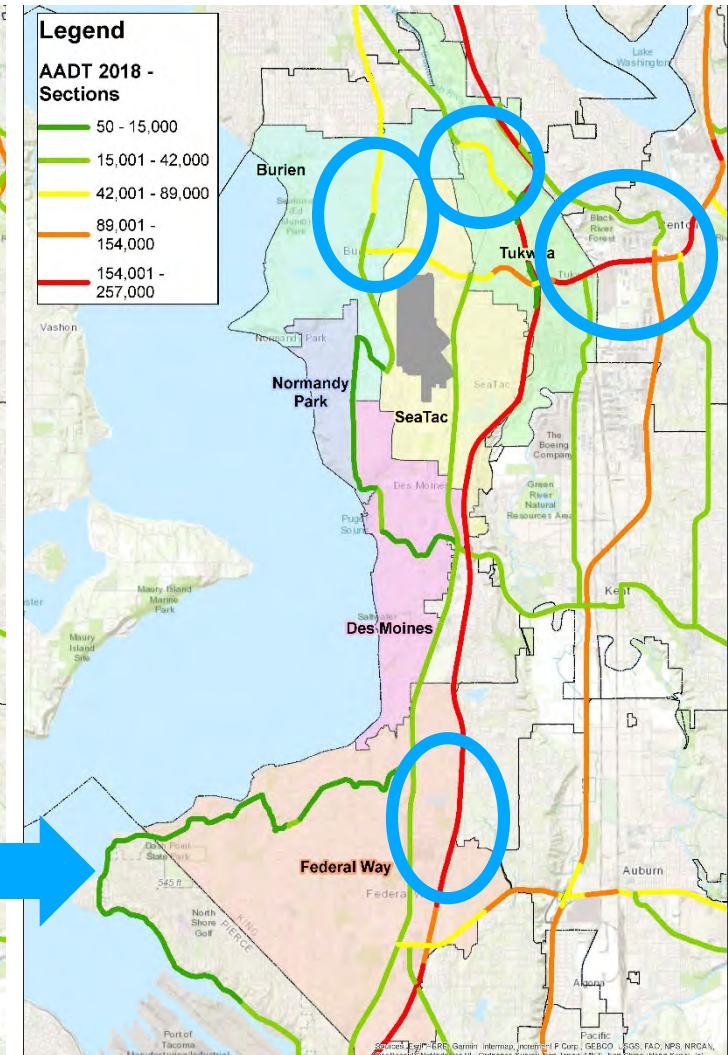
Major Arterials – Traffic Sections

- Annual Average Daily Traffic
 - Source: 2018 & 2009 *WSDOT Traffic Geoportal (TGP Traffic Sections)*
 - All directions of travel
- Areas of congestion
 - Burien – Rte 509 towards Rte 518
 - I-405 east of I-5
 - I-5 in Federal Way (near commercial center)

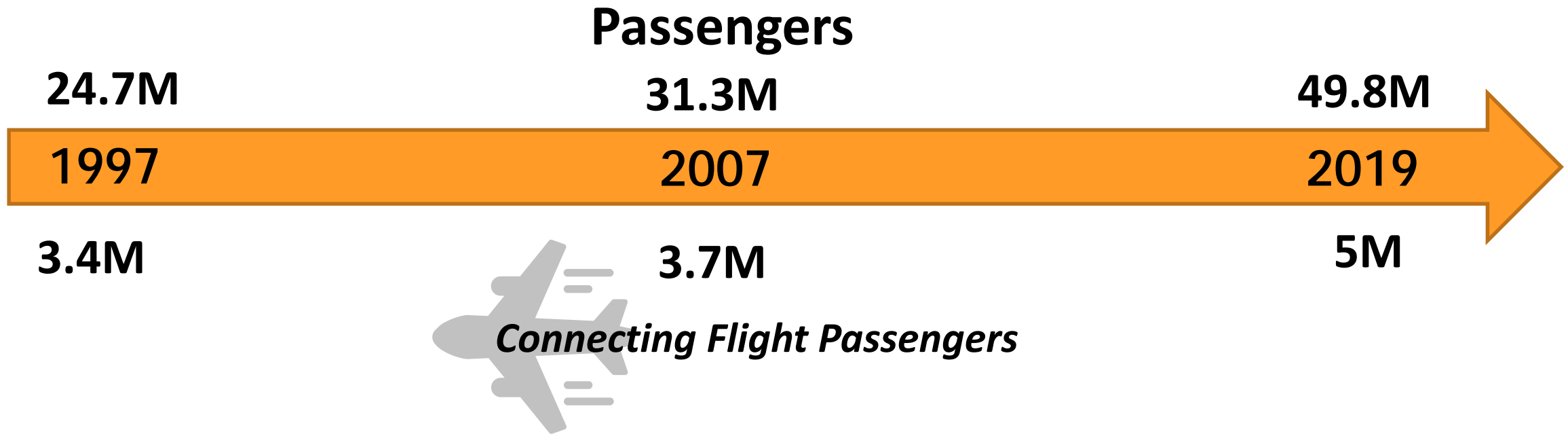
2009



2018



Passenger Volume



What are we looking at?



1997

2007

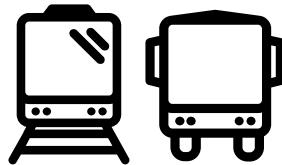
2019

Traffic



- Infrastructural changes
- Vehicle flow

Transit



- Transit network changes
- Systemwide improvements

Sea-Tac



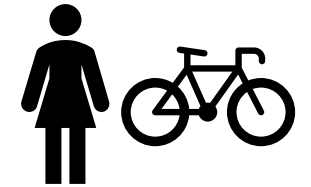
- Passenger movements
- Parking facilities
- Employee facilities

Parking



- Facility locations
- Accessibility
- System management
- Policy/Law

Pedestrian & Bicyclists



- Pedestrian & bicycle amenities
- Parking & transit accessibility

Major Arterials

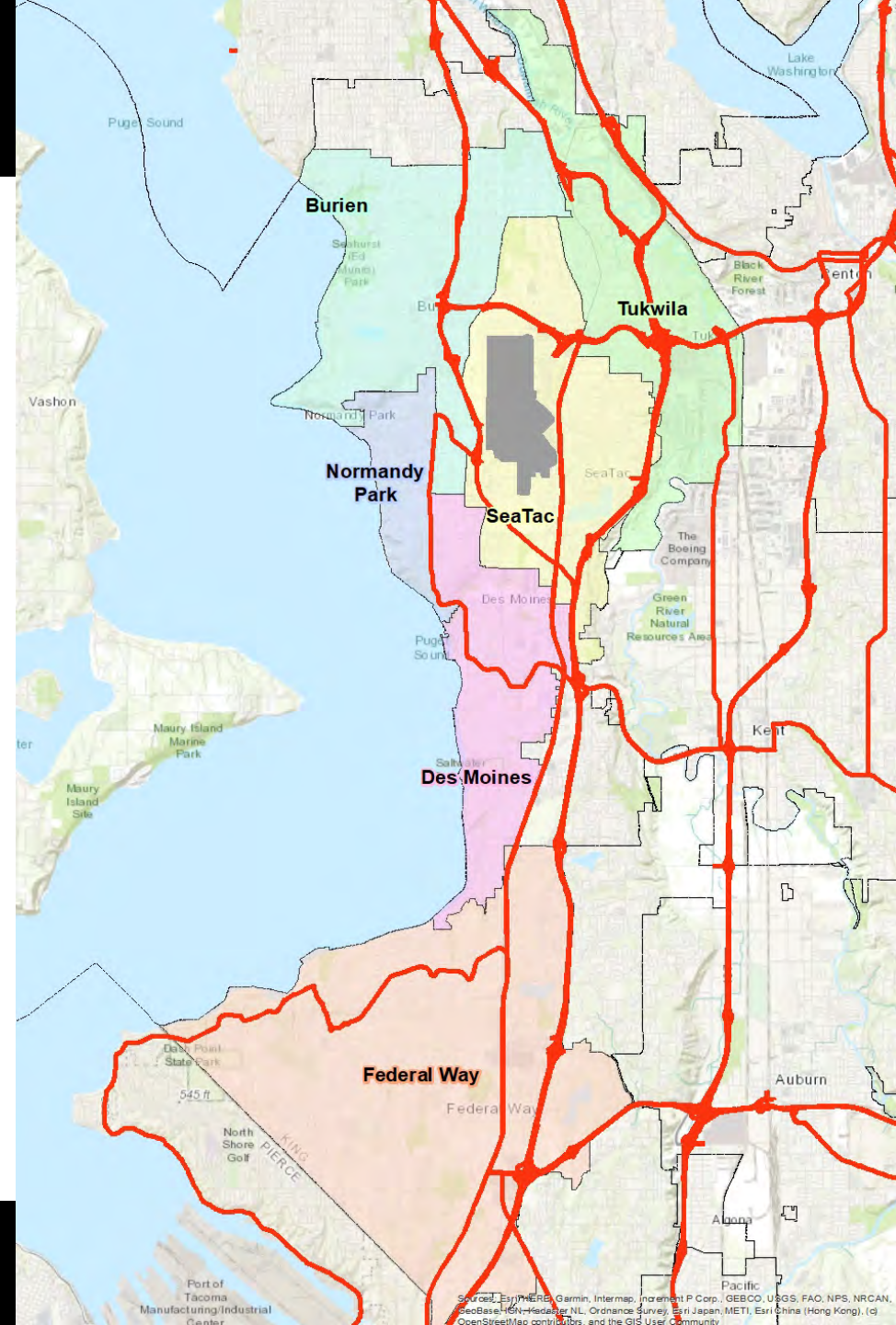


— 5 & 405



— 18, 99, 509,
515, 516, 518,
& 599

**And other major corridors*



Transit Service



Link light rail



Sounder
commuter rail



Regional
express bus

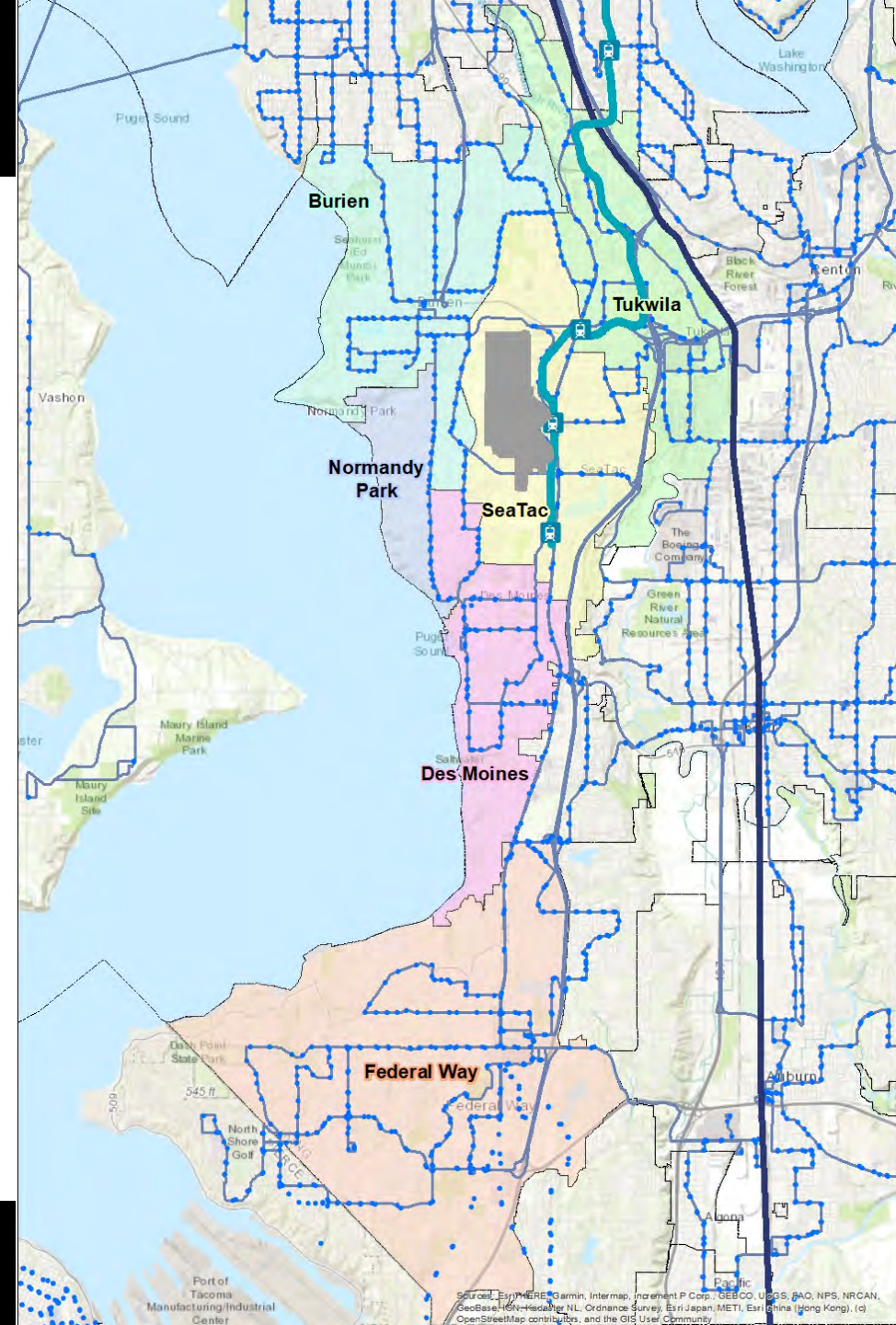


King County
METRO

— Local buses

RAPIDRIDE

— Bus rapid transit
(BRT)



Sound Transit



Rapid transit prioritization (since late 1990s)



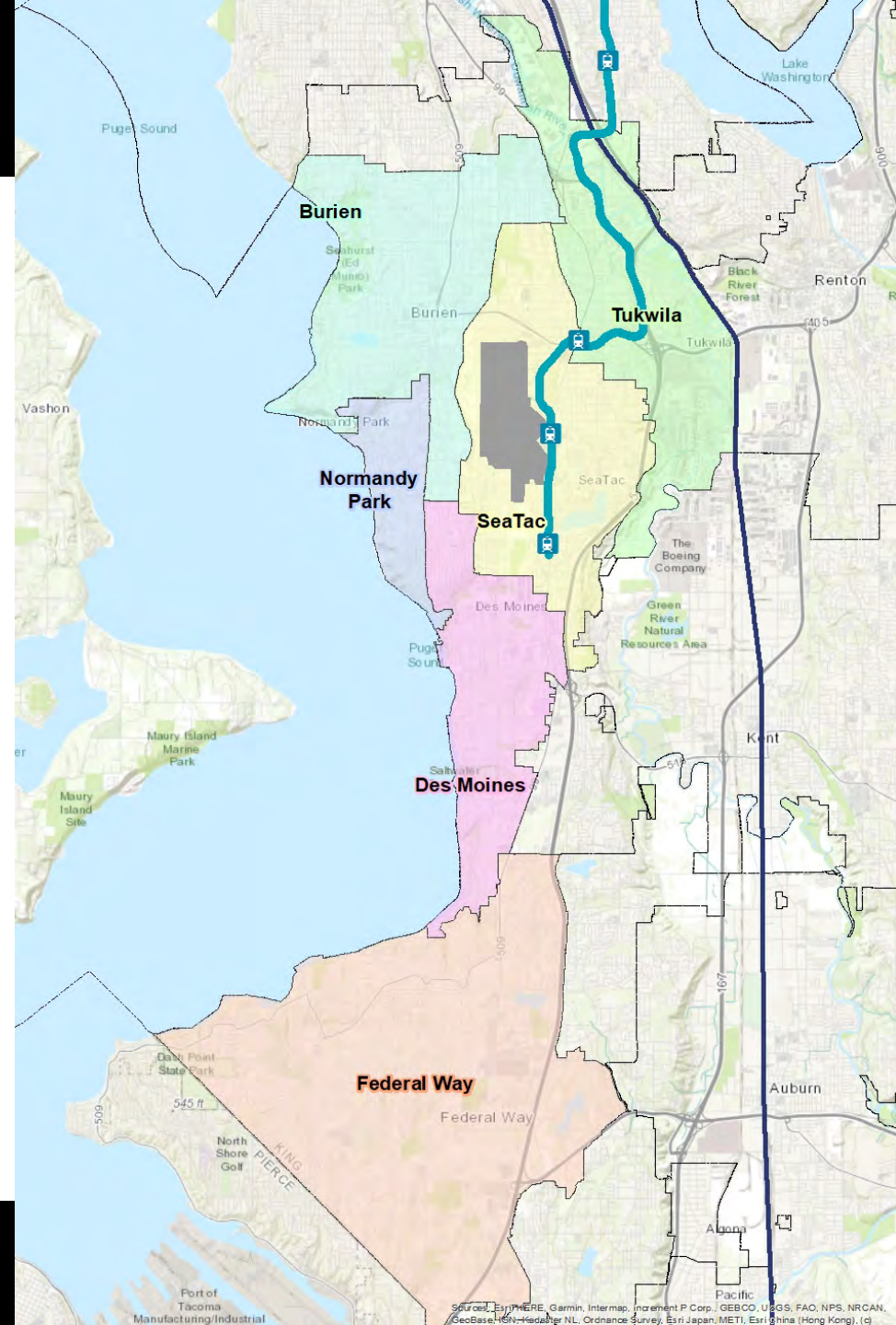
Link Light Rail (3 SeaTac Stations)



Express Bus Service



Sounder Commuter Rail



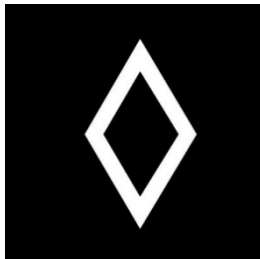
King County Metro Transit



Expanded
service



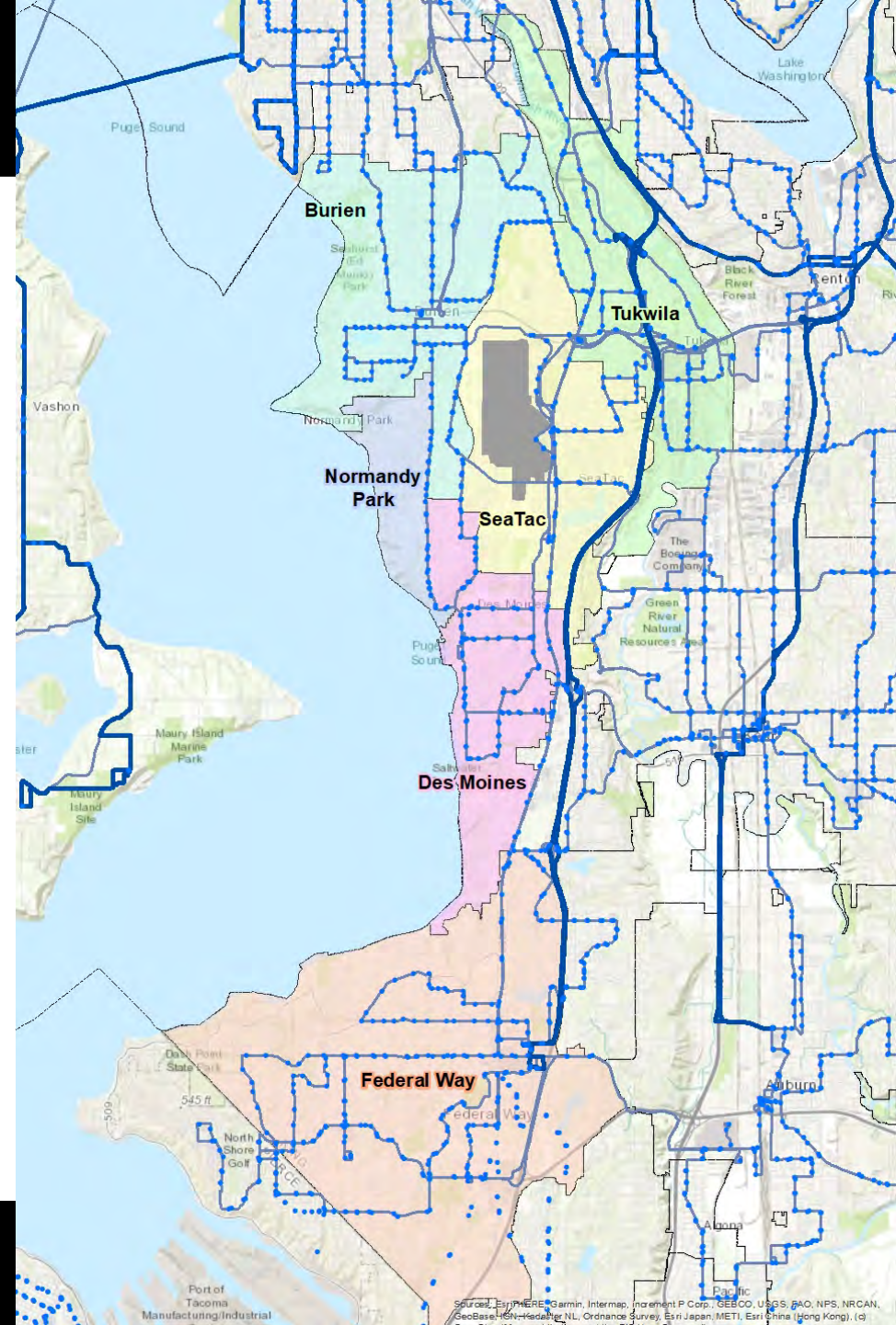
RAPIDRIDE
Service / Station



Transit/
HOV Lanes



Transit Oriented
Development



Sea-Tac Airport Changes



Expanded parking facilities (2000)



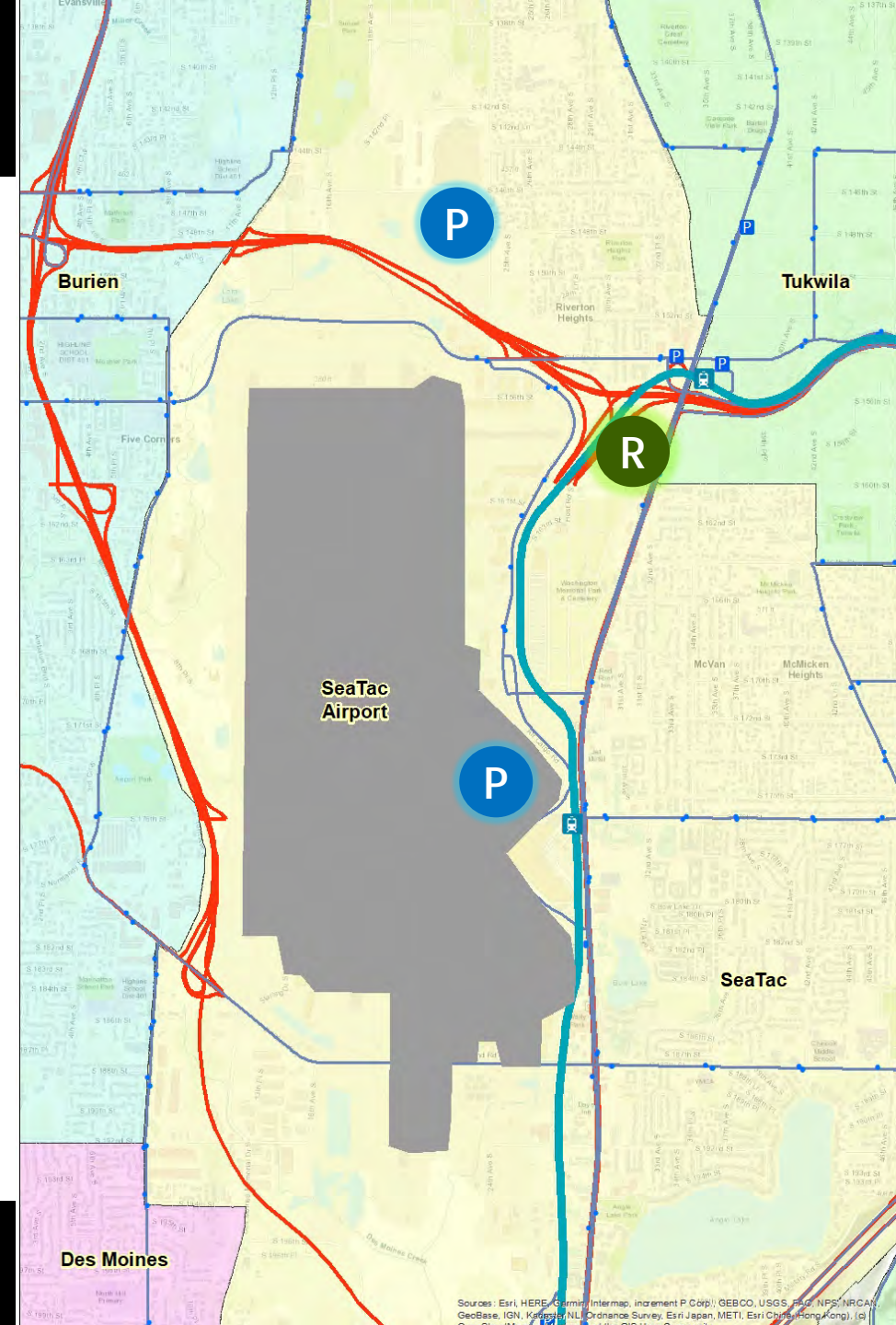
New rental car facility (2012)



Bus service frequency



Link Light Rail (2009)



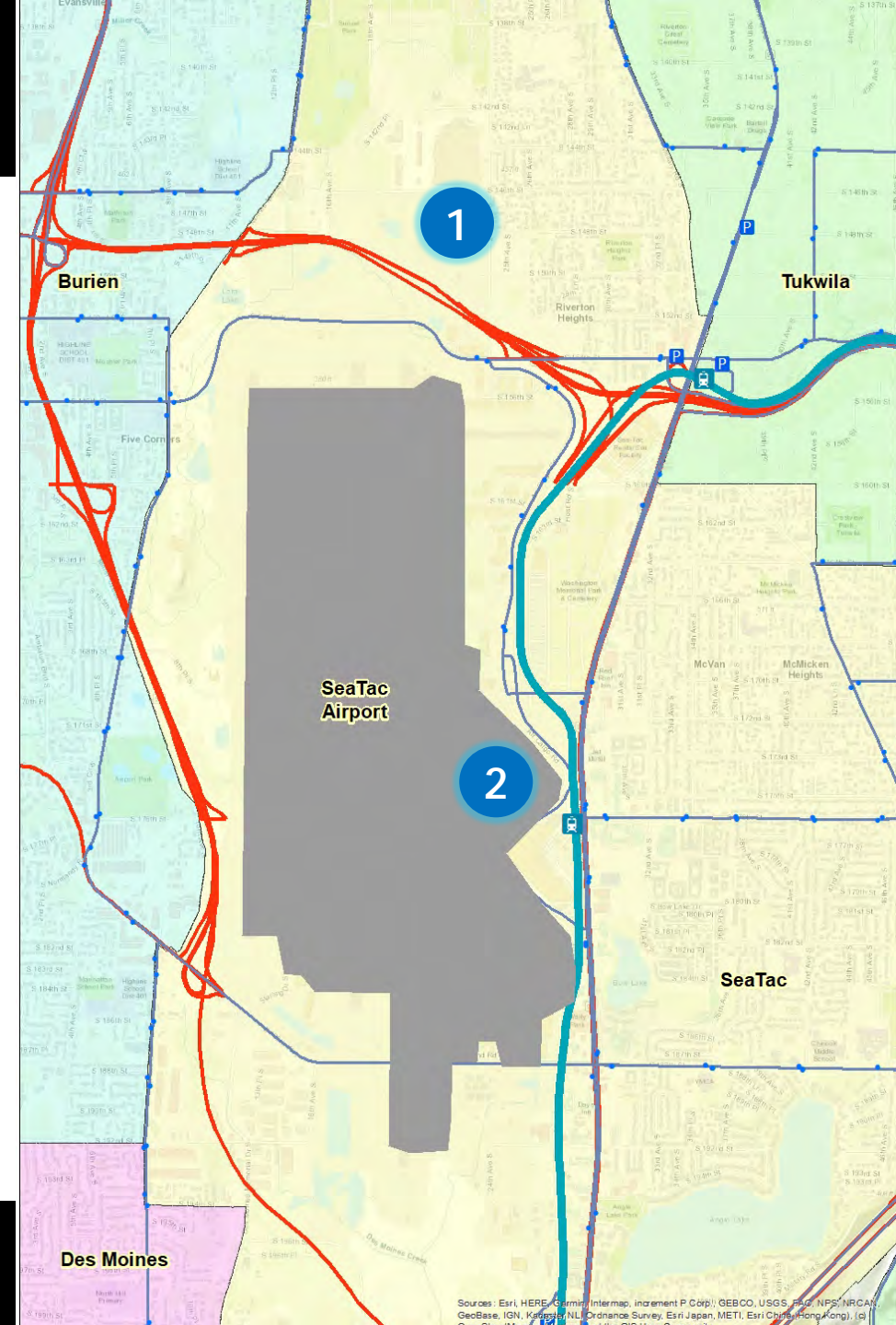
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c)

Airport Employee Parking

North Employee Parking Lot (1)

SeaTac Lot (2)

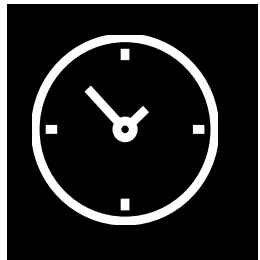
Total Spaces	~4,100 spaces	~13,000 spaces (allotted employee spaces)
Cost (month)	<ul style="list-style-type: none"> • Monthly (\$76/month) • Carpool Value Pass (\$30/month) 	Parking will be validated for employees
Incentives	<ul style="list-style-type: none"> • Bicycle amenities • Subsidized Transit Pass • Carpool, VanPool, & Emergency Ride 	



Off-Airport Parking Facilities (public)



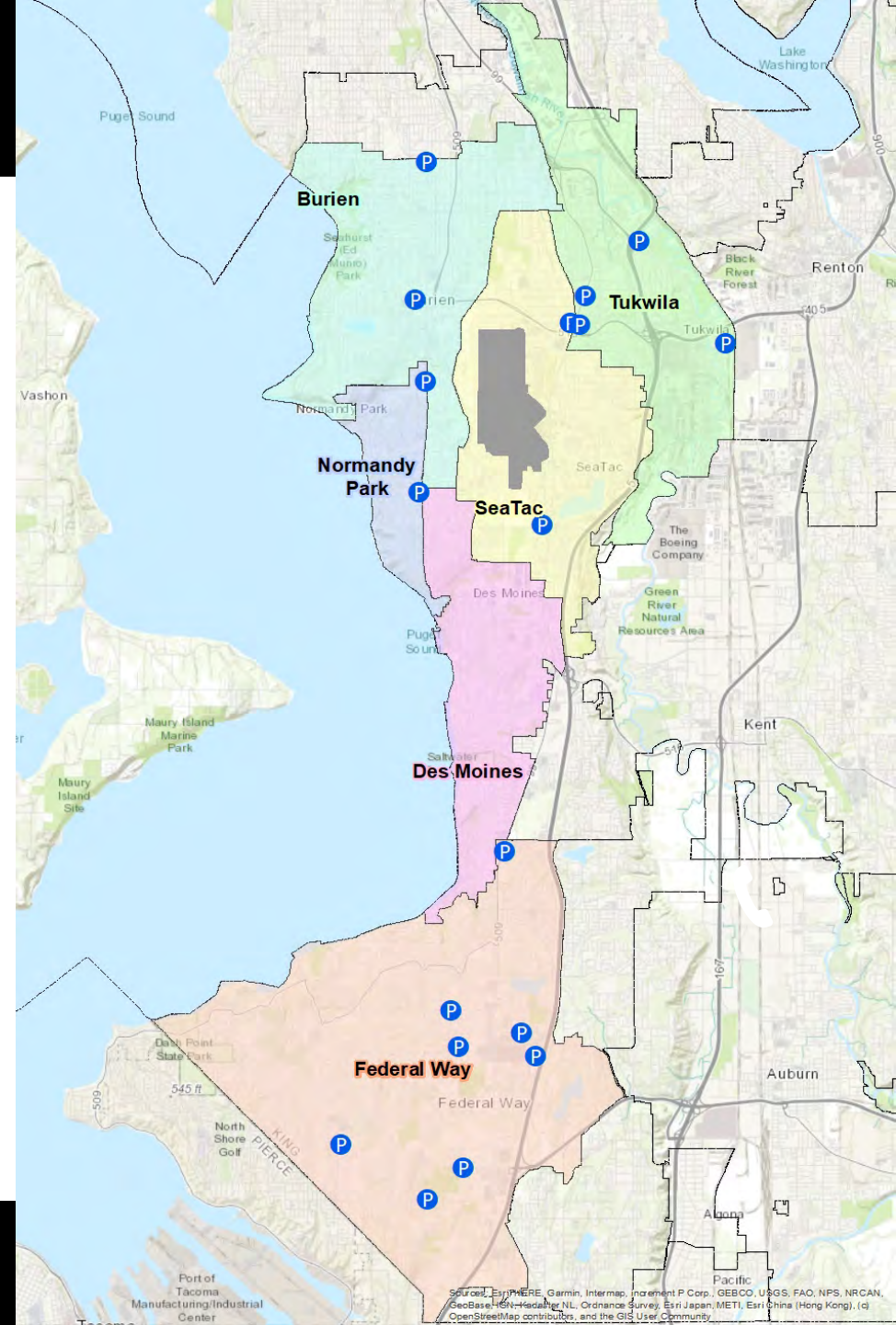
Increased park
& ride facilities



Limited long-term
parking options
(No Overnight Parking)



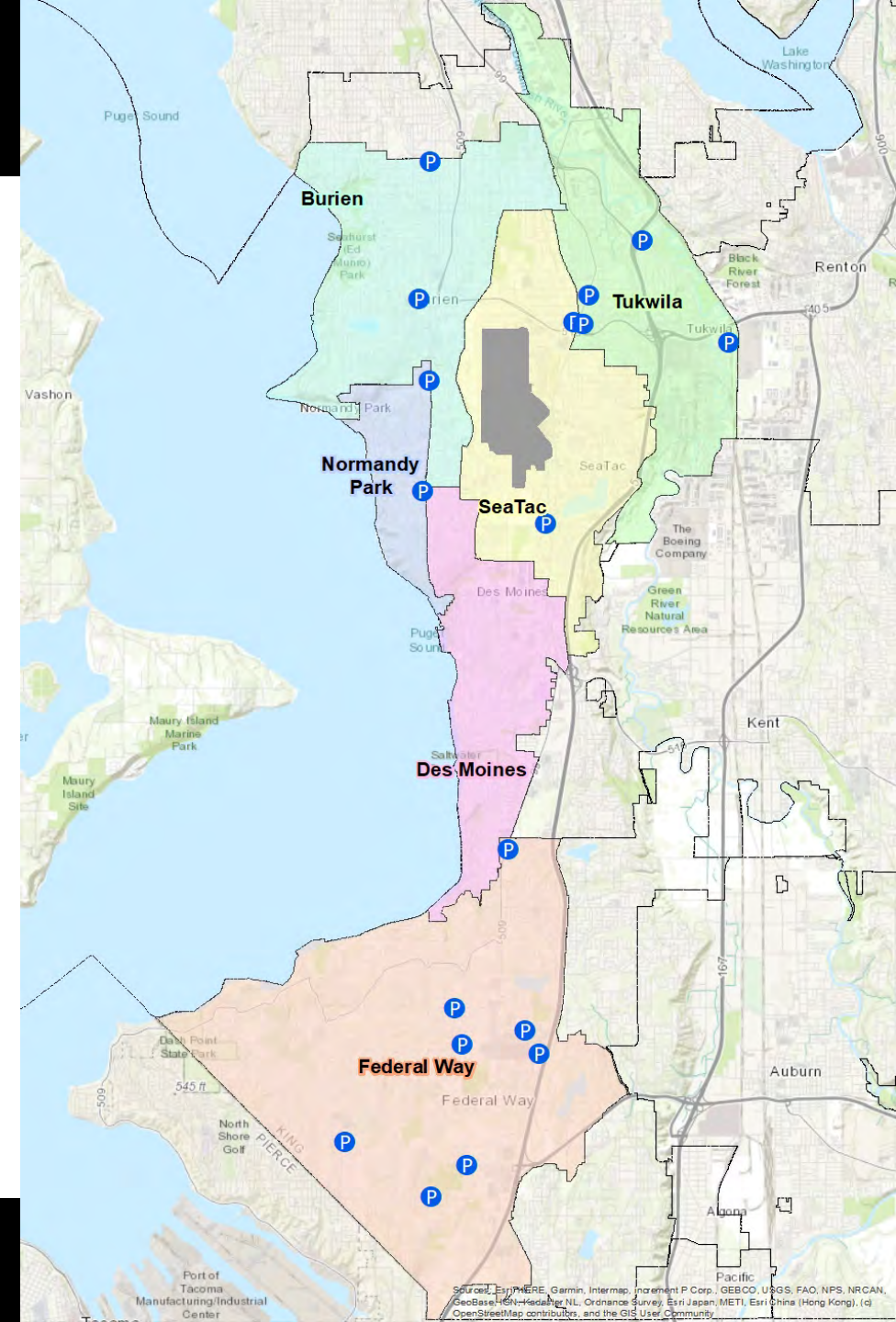
Transit
accessibility



Off-Airport Parking Facilities (public)

Park & Ride Lots*	
1997-2006	<ul style="list-style-type: none"> • Pre 1990: Federal Way/S 320th St, South Federal Way, Tukwila @ Interurban Avenue • ~2000: Twin Lakes • 2005 – Redondo Heights P&R • 2006 – Federal Way Transit Center
2007-2016	<ul style="list-style-type: none"> • 2009 – Tukwila Transit Center • 2009 – Burien Transit Center • 2013 – SeaTac Center Garage • 2014 – Tukwila Surface Lot • 2016 – Angle Lake Station

**Does not include church park & ride lots – project team continuing to look at on-going lease agreements*



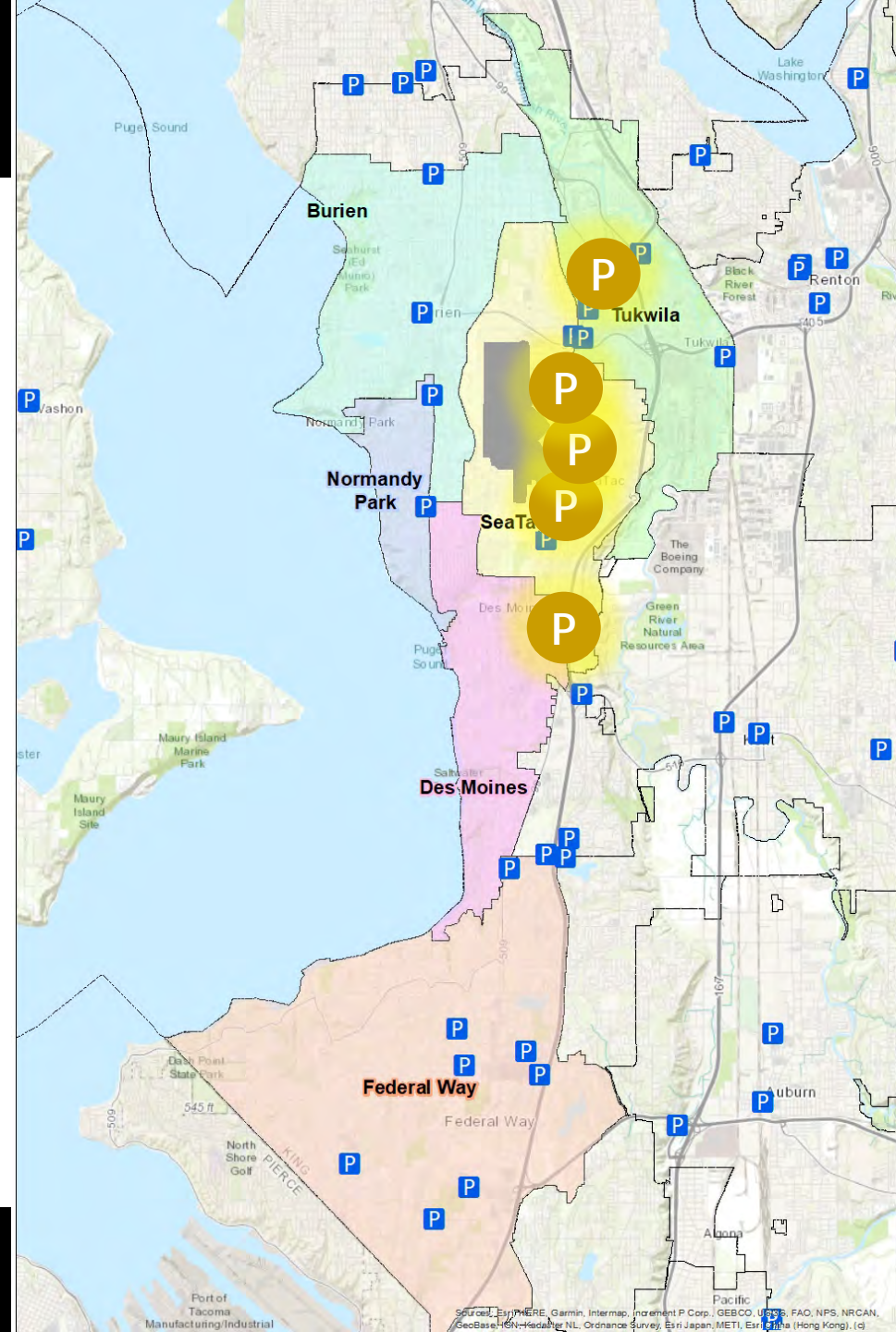
Off-Airport Parking Facilities (Private)



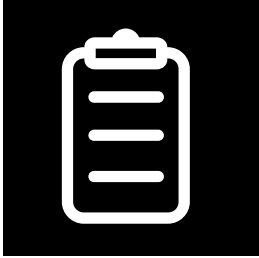
Park & Fly/
Private Ownership



Average Fee
\$10-30/day



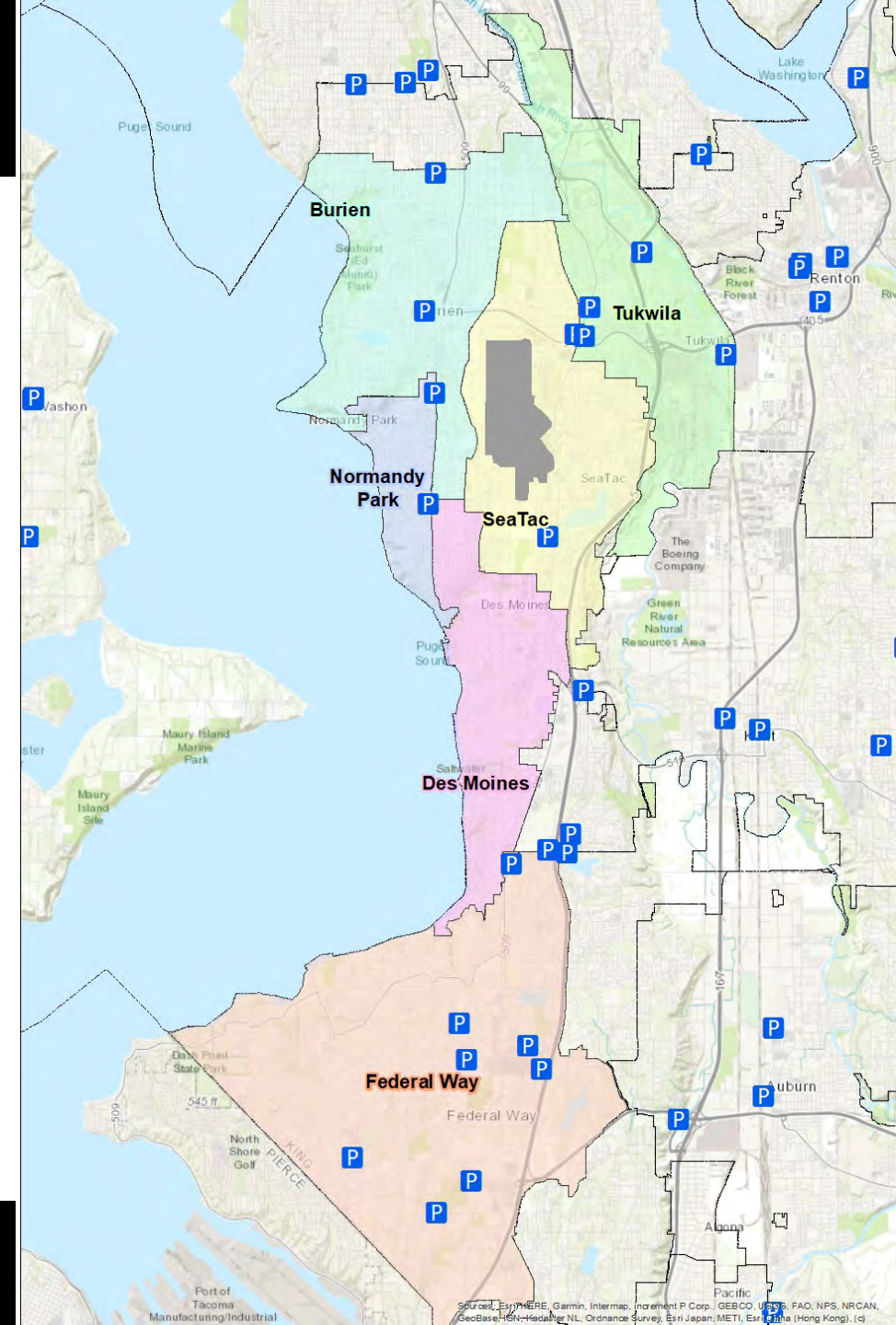
Off-Airport Parking (Policy)



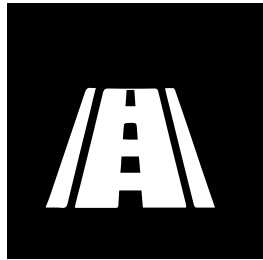
Parking standard adjustments
(shared allowances / reduced
quantity requirements)



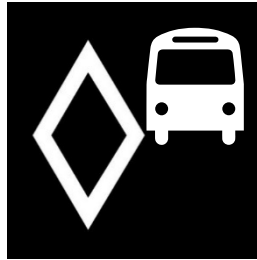
Increased enforcement &
Permit programs
(residential areas)



Preliminary Findings - Roadways



Airport Expressway



HOV Lanes



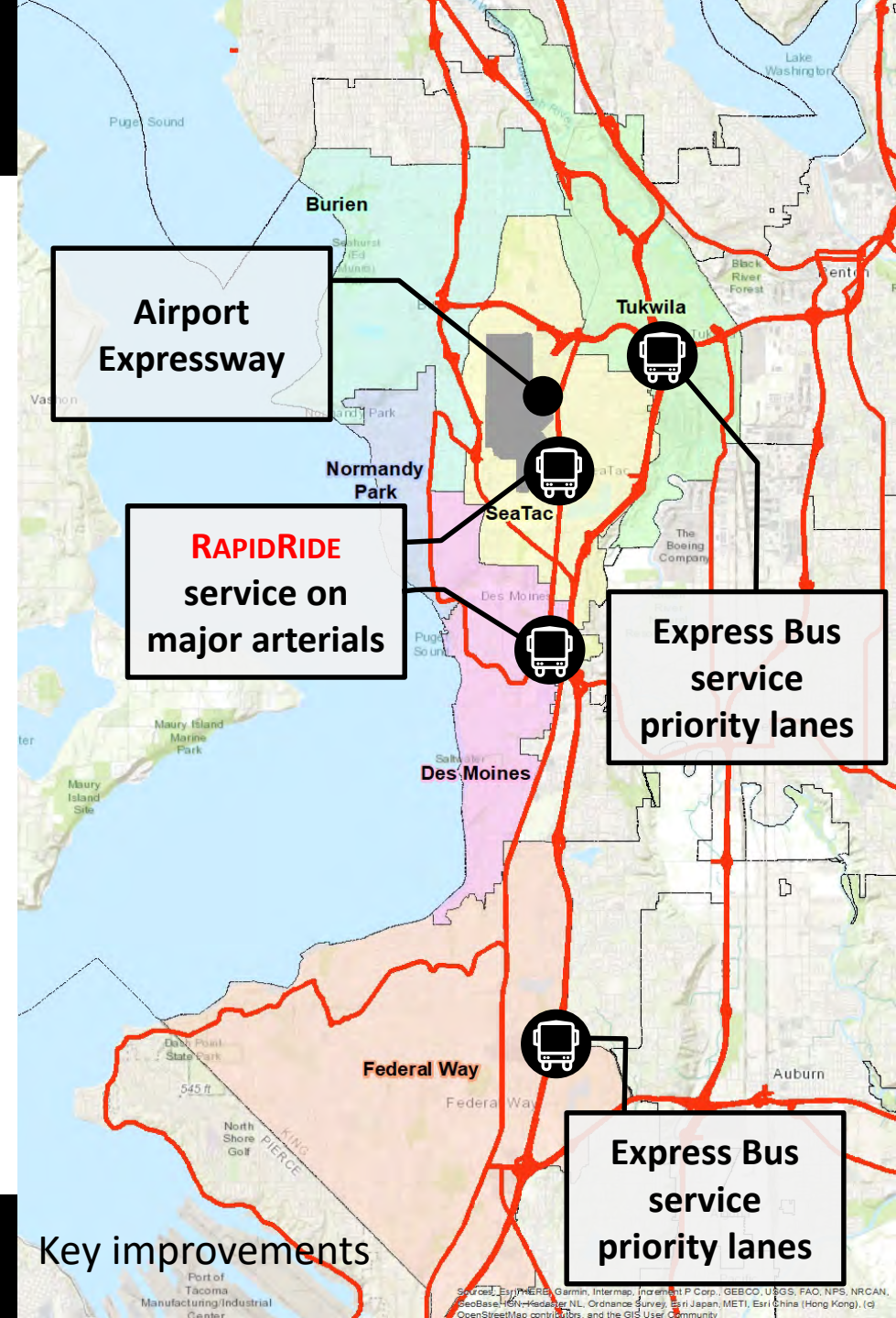
RapidRide roadway enhancements



Express Bus service priority lanes



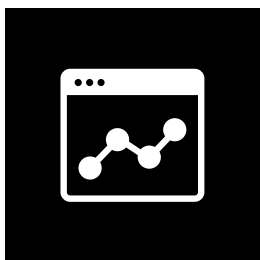
Improved pedestrian accommodations



Preliminary Findings - Transit



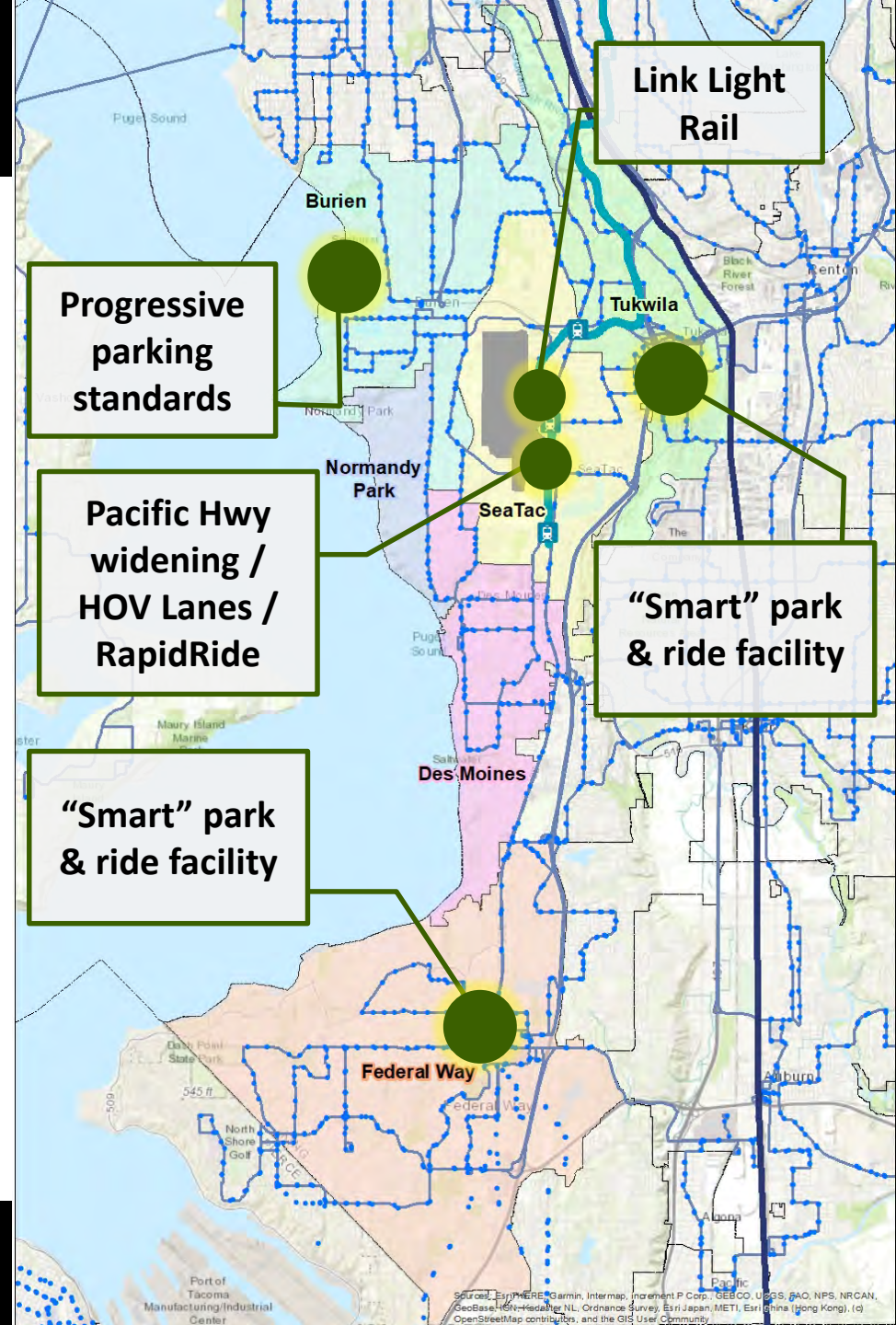
Expanded service
& improved
reliability



“Smart” transit facilities
(services: Ticketing, message boards)



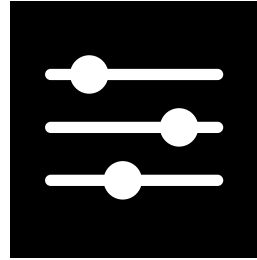
Consistent
regional
transit
ridership



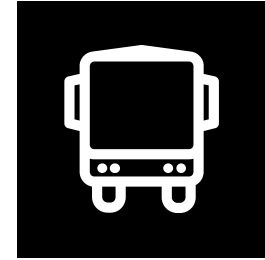
What's Next?



Map
comparison



Mode Shift
Trends



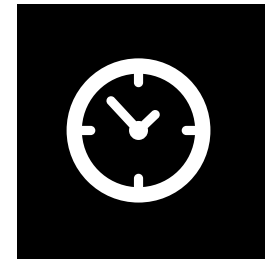
Transit
Ridership Data



Annual Daily
Trips



Queue
Analysis



Travel Times