Communications Plan for the Portland Metro Region

prepared for

TransPort

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Metro

prepared by

DKS

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1. EXECUTIVE SUMMARY

The project team developed this plan to support the longer term intelligent transportation system (ITS) telecommunications needs for the Portland metropolitan region. The plan supports the service areas of Traffic Control, Traveler Information, Incident Management, Maintenance and Construction Management, Public Transportation, and Archived Data Management. A strong regional communications network is also the backbone of the Smart City. This network supports not only those applications listed above, but it is a key requirement for new emerging Smart City applications such as Connected and Autonomous Vehicles.

The region has a history of developing collaborative relationships to leverage telecommunications investments. This plan helps to further advance that culture. This plan will also help leverage investments and support improved mobility throughout the region.

The project team used a three step process to develop this plan. The team worked with the region to:

- Document the current state of infrastructure
- Understand future needs of ITS as well as technology influences
- Develop recommendations for future investment

This plan provides opportunities for data sharing and improved resiliency through diverse fiber optic routes.

The plan also supports route and ring diversity to provide a higher degree of resilience to failures. Agencies are increasingly dependent on telecommunications to enhance mobility. The region needs more options to determine mechanisms to protect against disruptions to the network that are beyond our control such as physical fiber optic cable cuts or breaks.

The plan identifies over 80 route miles of priority projects and represents a capital investment of just over $24 million.

The existing and planned communications network maps provided in Appendix A provide a useful tool for agencies to draw upon as they request funding and determine project priorities. Metro, the metropolitan planning organization (MPO) for the Portland region, will work with partners to pursue funding opportunities to invest in the region's communications infrastructure. The Regional Transportation Plan incorporates the goals of the Transportation System Management and Operations plan that lays the foundation for advancing communications for Smart City and ITS innovation, new transit services and smarter signal infrastructure. Metro leads the process to make investment decisions. Metro convenes agency stakeholders through TransPort, a subcommittee formed under the policy leaders in the region. This provides the decision-making structure to allocate limited funding. TransPort includes cities, counties, transit operators, ODOT and FHWA. Metro supports stakeholders through a partner-led process to develop the criteria to prioritize investments. Projects are assessed based on the criteria to weigh the needs and benefits of each investment.

This Communications Plan includes the background and scope of the communications plan, a review of existing conditions, description of stakeholder workshop input, future ITS and communications trends, communications best practices, how this communications plan aligns with regional and local ITS plans, and priority project recommendations.

2. BACKGROUND AND SCOPE OF COMMUNICATIONS PLAN

The communications plan is meant to leverage regional investments strategically to support the longer term ITS investments identified in parallel with the development of this plan. The plan directs individual capital investments in communications infrastructure within the region to achieve mutually beneficial outcomes. This outcome is a robust regional multimodal communications network that will facilitate ITS projects in the Portland metropolitan region for the next 10 years.

The project team used a methodology to develop the communications plan that included developing:

- An existing regional ITS communications infrastructure inventory
- A clear vision of required ITS communications infrastructure within the timeframes and geographic constraints of the plan
- A master list of projects and budgets that represent progress towards the longer term plan vision.

The approach to the development of the plan included documenting the current state of the region's communications infrastructure as well as future operational needs and opportunities to enhance capacity and reliability of the network. The existing conditions were determined by obtaining, sorting, and summarizing the information provided in a map based format and soliciting feedback from all stakeholders. This feedback provided the framework for the stakeholder workshop.

The project team led a stakeholder workshop to discuss needs and opportunities and to gather route specifics where fiber optic infrastructure will benefit the region. This included identifying where individual agencies are planning to build communications infrastructure or ITS specific projects through their own funding mechanisms. Based on the inputs from the workshop, fiber optic infrastructure plans were developed and projects recommended including timing and budget. The projects provide guidance to the region as funding becomes available or will be used as the basis for funding requests. The plan will also be used to:

- Support future project plans and budgets
- Maintain comprehensive view of regional plans
- Build consensus for high priority regional investments
- Maximize investments
- Focus on areas of interconnection and synergy
- Avoid potential duplication of investment and construction (dig once policy).

3. EXISTING CONDITIONS

The existing conditions were determined by obtaining, sorting, and summarizing the information provided in a map based for and soliciting feedback from all stakeholders. The type of information received varied by agency and considerable consultation was required to consolidate the information to be used as a basis for planning. It is recommended that the region develop a simplified methodology for coordinating and synthesizing the information moving forward.

3.1 Inventory and Map of Communications Infrastructure

Some of the key stakeholder agencies that operate traffic control equipment or have fiber optic communications infrastructure across the Portland metropolitan region include:

- City of Beaverton
- Clackamas County
- C-TRAN
- City of Gresham
- City of Happy Valley
- City of Hillsboro
- City of Lake Oswego
- City of Milwaukie
- Multnomah County
- ODOT
- City of Oregon City
- City of Portland
- Port of Portland
- City of Sherwood
- TriMet
- City of Tigard
- City of Troutdale
- City of Tualatin
- Washington County
- City of West Linn
- City of Wilsonville
- WSDOT

Although some agencies in the region use wireless communications for portions of their network, fiber optic cable plant is the focus of the regional communications network and so wireless communications links are not included in the existing conditions inventory.

It is noted that commercially available wireless networks (4G and soon 5G) are available to provide broadband connectivity for some applications, however, a separate analysis of the applicability of use of these wireless networks, on an application by application basis is required. Unlike fiber optic owned infrastructure, the cost to activate commercial wireless networks is low, however since commercial wireless network operators charge monthly network fees based on the volume of data used, the deployment of these networks to meet Intelligent Transportation Systems communication needs should be carefully evaluated against the expected monthly data transmission volumes that are forecast. The decision to deploy commercial wireless network connectivity versus fiber should be made based on long term communication needs in the particular location and the long term total cost of ownership and operations of both a fiber based solution as well as a commercial wireless solution.

The geospatial data file received from each agency was categorized into existing, future/planned fibers, and copper cables/conduits based on available information within the data table. Existing conduit locations with twisted-pair copper interconnect cable are included in the inventory since the conduit may be re-purposed for fiber optic cable use in the future if deemed appropriate by a field investigation.

Agencies reviewed maps created from their geospatial data and the project team incorporated the comments. Feedback from agencies revealed commercially available dark fiber available for use. This information is captured as ‘Potential Dark Fiber’ on the maps, however this needs to be verified as to existence, as well as terms and conditions of use.

Due to inconsistency in format of the information provided, the GIS database entries could lack some relevant information such as status, type, or identification number. The net result is that the level of information available for each agency’s data is different. All of the data is now contained in shapefile polyline layers along with the locations of Transportation Operation Centers, major arterial roads, freeways, city boundaries, county boundaries, and the Metro area boundary.

This information is consolidated into:

- Map 1: Existing & Planned Fiber – Portland
- Map 2: Copper & Conduit – Portland
- Maps 3 through 7: Enlargements of Map 1 by area of the region

Maps are provided in Appendix A.

3.2 CTIC Summary

The Cooperative Telecommunications Infrastructure Committee (CTIC) was established through an intergovernmental agreement (IGA) in 1999 for coordination of communications infrastructure for transportation and public safety uses to support the goals and operational missions of member organizations. The purpose of the CTIC is to coordinate the use of network assets, such as funding, physical assets, rights-of-way, equipment, and labor in such a way as to benefit the member agencies whenever practical and avoid the development of duplicative network investment. The physical asset shared amongst the CTIC members is primarily fiber optic cable.

Within the CTIC there is an Executive Committee comprised of one representative from each member agency who votes on their agency's behalf. The Executive Committee establishes collaborative network architectures, designs, implementation plans, expansion plans, and maintenance plans to create a regional communications network infrastructure to serve all member organizations. They also suggest minimum standards for network construction and network operations and amend and add to their body of collaborative rules as necessary.

The fiber optic communications network developed by the CTIC supports a number of uses such as:

- The Intelligent Transportation System (ITS) Network for the Portland-Vancouver area
- ODOT communications to CCTV video and variable message signs
- TriMet operations
- The City of Portland Integrated Regional Network Enterprise (IRNE)

Members of the CTIC currently include[1]:

- City of Beaverton
- City of Gresham
- City of Portland
- Clackamas County
- ODOT
- TriMet

Once a member of the CTIC, typical agency responsibilities include:

- Sharing communications infrastructure with the member agencies under the terms and guidelines established by the Executive Committee

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[1] Washington County attends CTIC meetings, but is not currently an official member and does not participate in voting. They are "sponsored" by ODOT due to the connection to the Regional ITS Network.

- Leveraging financial assets where possible to create shared communications infrastructure
- Providing access to rights-of-way to other member agencies for the purpose of installing and maintaining infrastructure under the terms and conditions established by the Executive Committee, unless restricted by existing agreements
- Actively maintaining shared communications within rights-of-way to maintain minimum service levels established by the Executive Committee
- Providing preliminary project plans and specifications on construction projects involving communications to the CTIC for review.

Allocation commitments for sharing fiber optic cable are made by member agencies in writing using a Fiber Optic Route Assignment (FORA) form. Any member agency may terminate their participation from the IGA at any time after giving 90-day advance notice. However, any allocation commitments made by the withdrawing agency on FORA forms remains in full force and effect for the time period stated on the forms.

Appendix B includes some additional ITS Network guidelines and policies.

3.2.1 ITS Network Management Team

The CTIC is the group that coordinates on issues around the physical plant layer of the regional fiber assets, as described above. In addition to CTIC, regional coordination around the network layers of the regional communications system is performed by the ITS Network Management Team.

4. STAKEHOLDER WORKSHOP INPUT

A stakeholder workshop was held on September 14, 2016 with the attendees listed in Appendix C. Workshop attendees were presented with a brief overview of the goals of the workshop, then asked to review existing fiber optic cable, copper cable, and conduit infrastructure maps that were provided by the project team.

Workshop participants were broken into two groups and then asked to identify where the region needs additional fiber optic cable connectivity. The participants identified both local and regional needs in terms of future fiber optic cable connectivity requirements and prioritized projects based on both regional and local needs. The two maps were then merged and reviewed with the full group and adjustments were made to the fiber optic communications plan.

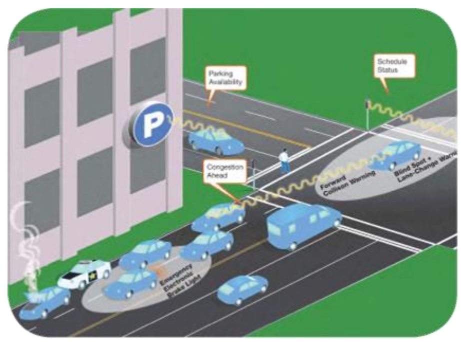
Areas of focus included:

- Gaps and bottlenecks
- Center-to-center connections
- Redundancy
- Future corridors with significant planned ITS infrastructure
- Age and capacity issues

5. FUTURE ITS AND COMMUNICATIONS TRENDS

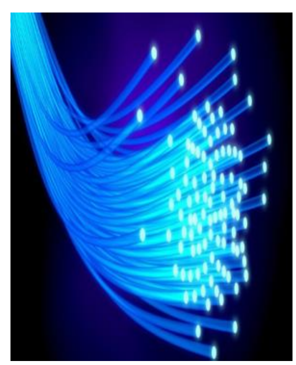
A number of trends influence how we plan telecommunications to support ITS. These trends fall into two broad categories:

1) ITS technology trend influencers:



- Connected vehicle trends that call for higher density of roadside devices to support vehicle-to-infrastructure (V2I) systems
- Video based algorithms that utilize both onsite and remote processing
- Interagency center-to-center (C2C) data sharing needs that allow for better real-time and interagency collaboration
- Automating performance measures that allow for real-time data collection and reporting to ensure optimized operation.

2) Communications technology trend influencers:



- Video (CCTV) demands pushing network capacity expansion including overall bandwidth needs and fiber optic strand counts
- Increasing number of roadside devices (wireless and wired), which require network connections/ gateways.
- Reliability and security are now more critical creating a stronger need for network redundancy and additional physical/ logical security investment
- Commercial cellular operators offering data plans suitable for machine-to-machine communications (Internet of Things (IoT) device target market).

6. COMMUNICATIONS BEST PRACTICES

Understanding best practices is critical to implementing a strong ITS Communications Plan. This section provides a summary of best practices regarding redundancy, network architectures, future communications network architectures, and increasing network capacity using multiplexing technologies.

6.1 Redundancy

Fiber optic cable networks are often initially constructed as point-to-point connections based on an immediate need to connect two distant locations together with telecommunications services. As networks evolve and expand, and support mission critical applications, it is desirable to create network architectures to support highly available applications that demand minimal downtime. Most approaches focus on redundancy and best practices can be categorized in four areas as described in the following subsections:

- Network Equipment and Power Redundancy
- Fiber Optic Route Redundancy
- Route Diversity
- Ring Diversity

6.1.1 Network Equipment and Power Redundancy

The network equipment that is used to light the fiber strands is a single point of failure, since a failure of the electronics, or even a portion (port) on the electronics that is connected to the fiber optic cable can result in an outage of the entire communications link. Care must also be taken to ensure that power supplied to the equipment is from a reliable source, backed up utilizing Uninterruptable Power Supply (UPS) equipment, normally consisting of an inverter/ rectifier combination and batteries. While not the focus of this communications plan, it should be noted that network equipment and power redundancy play an important role in any strategies implemented to improve network reliability by using redundancy techniques.

6.1.2 Fiber Optic Route Redundancy

The practice of fiber optic route redundancy involves creating an alternate fiber optic communication path between two or more locations in order to prevent a physical fault in the fiber optic cable from creating an outage. This communications plan will focus on describing options to provide fiber optic route redundancy, (i) Route Diversity and (ii) Ring Configurations.

6.1.3 Route Diversity

The practice of route diversity involves creating physically separate routes (communication paths) of fiber optic cable between two or more locations such that if any single fiber optic cable becomes inoperable, the second (diverse) route will continue to provide connectivity between the locations. The most common cause of fiber optic cable failures (58%) are accidental “dig-ups” caused by construction taking place near the cable, typically by construction equipment such as a backhoe. In order to guard against these types of incidents, recommendations for route diversity include separating diverse routes by at least 25 feet of distance (the typical reach of a backhoe arm) to prevent route diverse fiber optic cables from being impacted by the same accidental dig-up. Note that to achieve the best possible route diversity, careful attention should be paid that this minimum separation distance is maintained at all points along the route, maintaining the 25 feet separation at all points along the route, including the final connection to the building (separated building entrance cables), and ultimately maintaining separate paths within the building (building risers) to the equipment room where the network electronics are placed. If separate building riser paths are not possible, alternative protection schemes can be undertaken, including placing each fiber optic cable in separate metallic conduit to minimize the chance of accidental damage when other cables are installed/ removed in the common building riser. Diverse network configurations with two nodes are also typically configured to operate in a two-node ring configuration as shown in Figure 1.

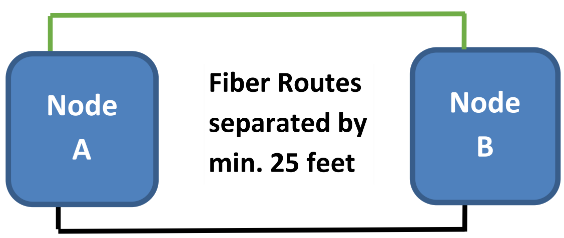


Figure 1: Route Diversity

6.1.4 Ring Diversity

While route diversity is traditionally used to improve the reliability of a telecommunications link between two locations, a ring diversity architecture is often used to create route diversity between several locations that require telecommunications services between them to function at a highly reliable level.

Ring diversity relies on creating a ring communications path between multiple locations [see Figure 2] and deploying network electronics that support operations. This is called a ring or ‘self-healing’ architecture. The diverse ring architecture relies on the ability of network electronics to sense when any communication path between two nodes has become inoperable (e.g. a fiber cut) and redirect network traffic around the ring in an opposite direction to allow network traffic from any node on the ring to reach any other node on the ring.

This approach requires careful planning of both the physical fiber optic cable routing between network nodes to ensure that all fiber connections between nodes do not share a common physical path (see route diversity guidelines above), and that the network electronics and communication protocols utilized will support the recognition of a network fault on any portion of the ring, and take action to re-direct traffic on the ring to ensure that all nodes on the ring maintain communications connections.

Common protocols for implementing ring diversity include Ethernet (IEEE 802.11); however, it should be noted that traditional spanning tree protocol of Ethernet will require time to 're-converge' the network and redirect network traffic. Vendors of communication equipment have implemented other standard protocols and in some cases vendor proprietary protocols to improve on the limitations of the spanning tree protocol. Common ring protection Ethernet protocols include resilient packet ring (RPR) [IEEE 802.17] [Ethernet ring protection (ERP) and Ethernet automatic protection switching (EAPS) RFC3619]. Please refer to [ITU-T-G8032] for additional information.

Figure 2 depicts a typical ring diversity configuration.

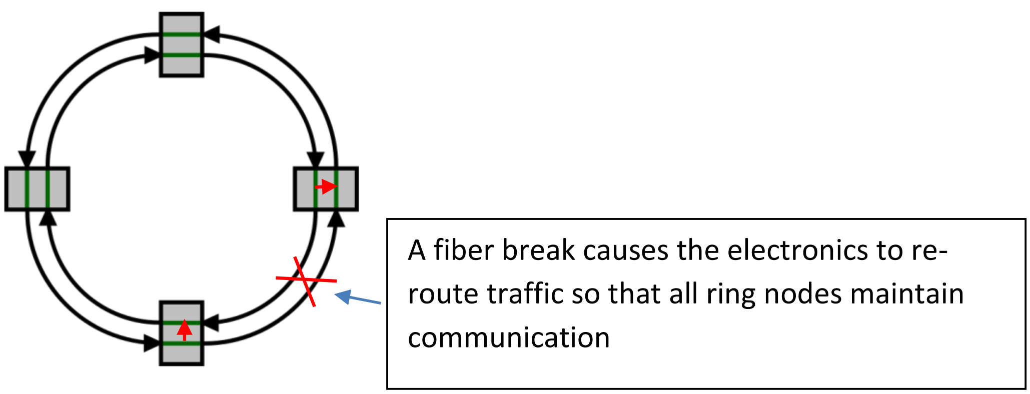


Figure 2: Ring Diversity (Typical)

6.2 Network Architectures

As the TransPort network grows and evolves, so should the network architecture evolve to support the objectives of providing high capacity bandwidth, utilizing diverse routes that create ring architectures to improve the overall reliability of the network.

Most TransPort centers are currently connected, or are planned for connection, in a ring architecture. Refer to the existing system architecture diagram shown in Figure 3.

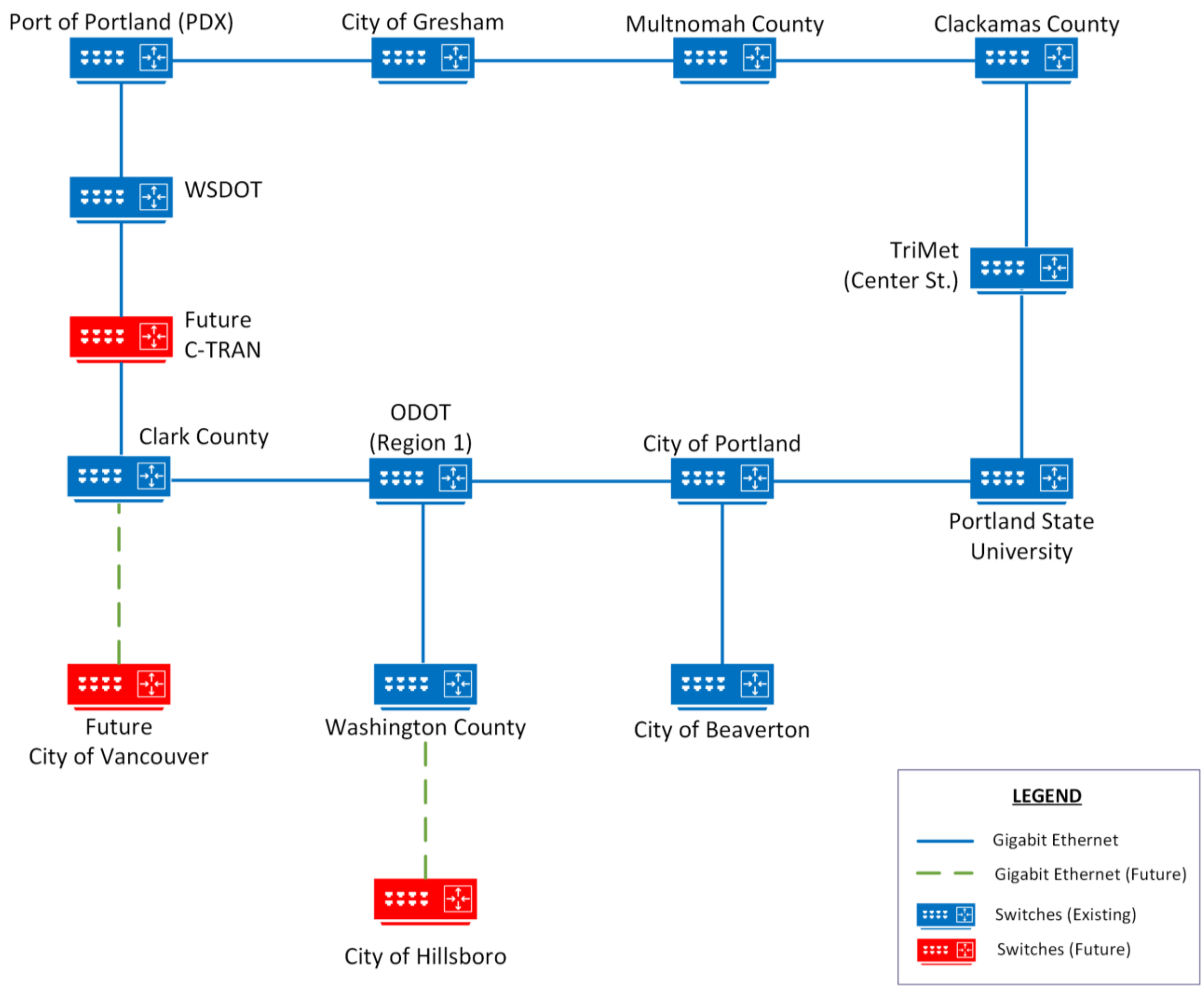


Figure 3: Existing ITS Network Architecture.

In order to manage the capacity and reliability of the communication between centers, it is recommended that:

- All centers that are not directly connected to the ring (Washington County, City of Beaverton, and City of Vancouver) be evolved to a ring architecture.
- The current single ring architecture be evolved to a multiple ring structure to allow for increased bandwidth between centers and improved reliability of the overall network.

NOTE: As discussed above, the ITS Network Management Team is ultimately responsible for making decisions about network architecture, timing of investment and determining the benefits and Return on Investment of any network architecture changes. This group will determine if, when and how to implement future network reconfiguration.

6.3 Future Conceptual Communications Network Architecture

Figure 4 illustrates the concept of a reconfiguration of the regional ITS network architecture that would incorporate the recommendations in the previous sections. This is not intended as an actual network architecture design, as that would be developed by the CTIC and the ITS Network Management Team. The final design could utilize only two rings, could involve even more rings or even could employ more of a mesh network. The order of the specific agencies, physical routing and network layer would all be determined and designed by CTIC and the ITS Network Management Team.

The particular conceptual network architecture illustrated Figure 4, provides for the creation of three distinct ring architectures to accommodate center-to-center communications, while providing network diversity and eliminating any single points of failure. In this example, three metro rings could be formed (West, East, and North) to accommodate this architecture. This example shows three hub locations: ODOT, City of Portland, and WSDOT where it is recommended that diverse fiber entrances be prioritized to improve network redundancy and survivability.

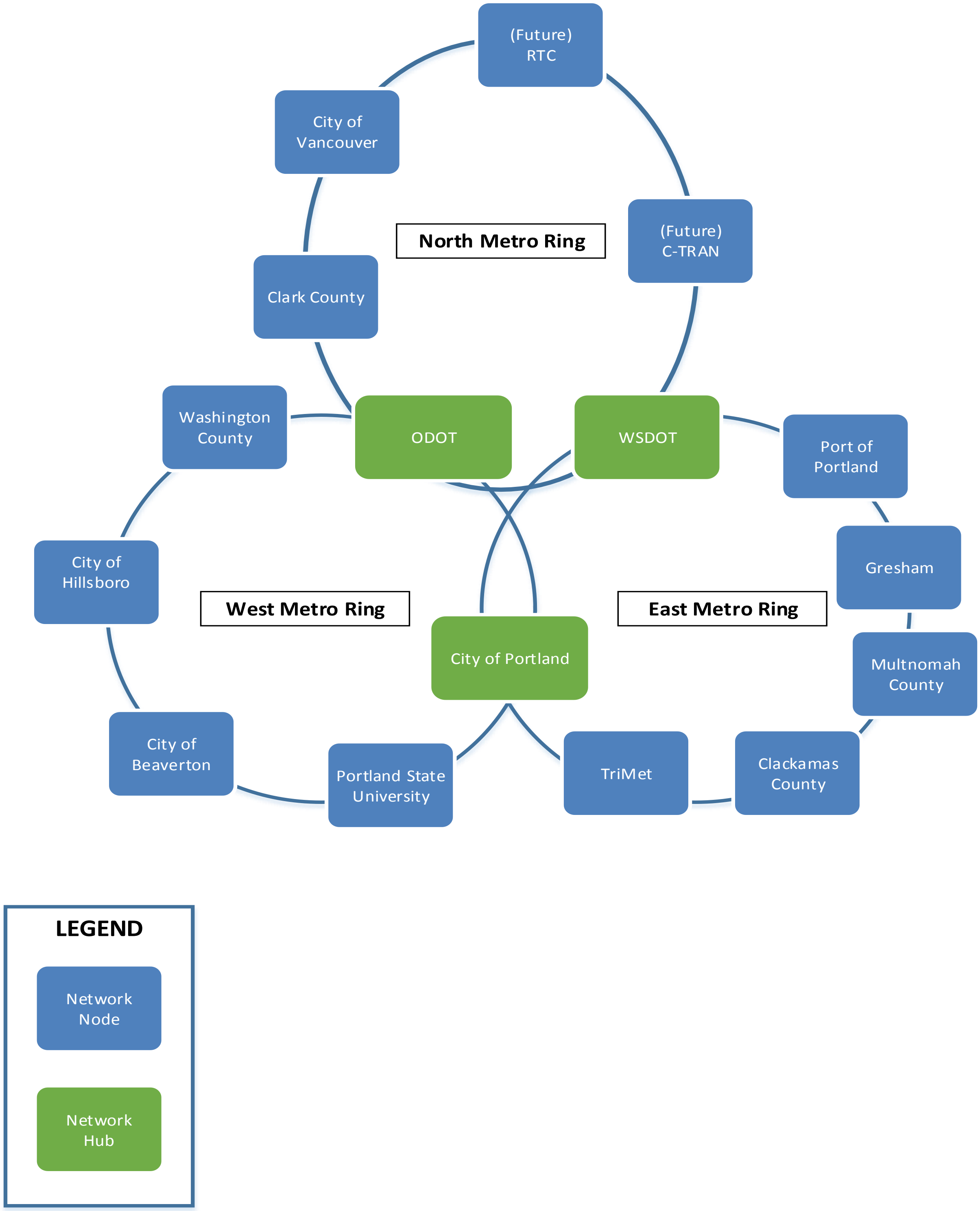


Figure 4: Future Concept of a More Redundant Communications Network Architecture

6.4 Increasing Network Capacity Utilizing Multiplexing Technologies

Multiplexing technologies, namely wave division multiplexing (WDM), allow the number of signals carried by a single optical fiber to be increased by separating signals into discrete wavelengths of light that each carry a unique 'channel' of communication. Wave division multiplexing is often deployed to make better use of existing fiber cables, effectively increasing the capacity of the fiber network, especially in sections of the network that are capacity constrained by the quantity of fibers available and construction costs to add additional physical fiber cables may be high. Some agencies in the Portland Region are currently using various types of multiplexing technology. The following sections describe some common types of multiplexing technologies.

6.4.1 Coarse Wavelength Division Multiplexing (CWDM)

CWDM, also known as passive multiplexing, is a process of combining multiple wavelengths into a single fiber strand. ITU standards (ITU-T G.692.2) specify 18 wavelengths from 1270 nm to 1610 nm that can be utilized by CWDM equipment to transmit and receive information. See Figure 5 for the CWDM wavelength grid.

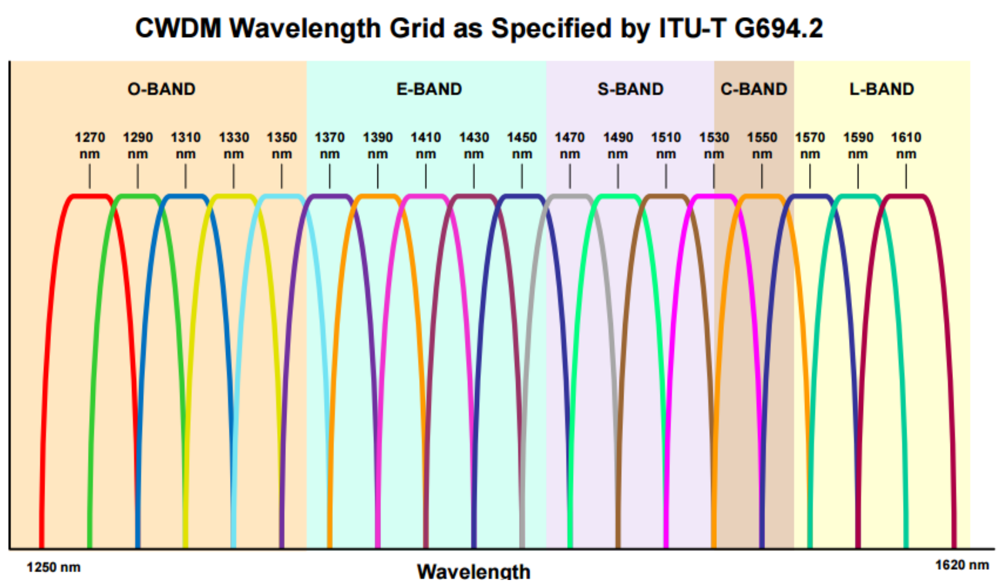


Figure 5: CWDM Wavelength Grid

The use of CWDM is an effective tool to increase the effective capacity of fiber optic cable networks to overcome capacity bottlenecks and defer expensive construction costs to add additional fiber strands. CWDM equipment normally functions over distances of less than 25 (although some vendors have equipment that may span up to 50 miles), miles, is normally passive (does not require power), and is relatively inexpensive (CWDM equipment can be purchased for $10,000 to $20,000, depending on desired channel capacity). It should be noted that inserting CWDM into an existing network architecture requires a careful review of transmitter/ receiver link budgets, and the upgrade of existing transmitter modules (e.g. SFP transceivers on electronics need to be CWDM compatible and selected to transmit on a particular optical CWDM standard optical wavelength).

6.4.2 CWDM Recommendations

The TransPort group, CTIC, and the individual stakeholders should all consider CWDM as an effective technology to alleviate short term bottlenecks, or in situations where available fiber strands are limited by high construction/ leasing costs. CWDM does add network complexity and introduce additional equipment costs, but it should be considered for situations where fiber strands are at or near capacity exhaust and for distances of less than 25 miles. If spare fiber strands are available, it is normally preferable to use those strands first versus deploying CWDM systems.

6.4.3 Dense Wavelength Division Multiplexing (DWDM)

DWDM, also know as active multiplexing, is also a process of combining multiple wavelengths into a single fiber strand. It offers the benefit of many additional channels (up to 73) compared to CWDM (18 channels). DWDM technology is often deployed along routes where extremely high capacity communications are required and/or along long-haul routes where it is desirable to minimize the number of fiber strands utilized and minimize the needs for optical regeneration/ amplification equipment along the route.

DWDM technology is based on active electronics. Extremely stable lasers are utilized and tuned to transmit on specific optical channels within the ITU Channel Grid. The initial configuration and ongoing maintenance of the electronics requires a high level of skill and attention. The equipment must be maintained in a stable, temperature controlled environment to provide proper ongoing operation. Careful attention to optical fiber splicing specifications is required to allow DWDM systems to operate without errors introduced from poor quality splices. In addition, the type of fiber, namely nonzero dispersion shifted fiber (NZ-DSF, ITU-T_G6.655) should be considered to support high capacity DWDM systems that will operate at the higher speeds of OC-48 (2.5 Gb/s) and OC-192 (10 Gb/s) over longer distances (greater than 35 miles).

Typical DWDM equipment costs range from $50,000 to $500,000 depending on the size and complexity of the system deployed. Specialized test equipment is also required to perform troubleshooting and maintenance activities on the system.

6.4.4 DWDM Recommendations

After reviewing the size, distances, and applications contemplated by the TransPort group and CTIC, it is recommended that DWDM technology be deployed as a tool to manage fiber capacity issues within the network under situations where CWDM may not be applicable and the costs to build additional fiber are extremely high or a fiber build is simply not possible. The costs and additional network complexity that DWDM introduces must be outweighed by the system capacity gains realized. DWDM should only be considered after several CWDM systems have been deployed along a given route and future capacity forecasts indicate that a DWDM system may be appropriate.

7. PRIORITY PROJECT RECOMMENDATIONS

The project team worked collaboratively with TransPort members to develop priority project recommendations. Priority projects are identified based on overall consensus, as well individual local agency priority. Route length was estimated to the nearest tenth of a mile in order to provide a cost estimate. All cost estimates assume new construction along the route. However, in some cases costs may be reduced by using existing conduit or over-lashing with existing aerial fiber. The availability and suitability of conduit will need to be verified during a detailed engineering/ field inspection phase. The following descriptions below provides additional detail on the assumed cost based on construction type.

- **Heavy urban environment - $500,000 per mile**.
  Description: Urban downtown area that consists of paved roadway, sidewalks, private right-of-way, and significant existing utilities. Trenching will require significant roadway and sidewalk repair. Horizontal directional drilling, while expensive and slow with existing utilities, is still likely a less expensive option.

- **Urban - $300,000 per mile**.
  Description: Inner suburbs with wider spaces but most of the public right-of-way is paved with sidewalks. Lower utility density should make horizontal directional drilling easier and it is basically the same cost as trenching in the shoulders and sidewalks, including repairs.

- **Aerial - $200,000 per mile.**
  Description: Assumes using existing utility and agency poles. If poles are overloaded and need to be replaced the cost increases significantly and underground installation becomes more feasible.

This section provides fiber optic cable sizing recommendations and identifies priority projects at the regional and local agency level.

7.1 Fiber Optic Cable Sizing

While the fiber optic cable sizing for new projects must go through a design phase to determine individual project requirements, it is recommended that new construction plans install at least a 96-strand fiber optic cable size. Since the actual cost of the fiber optic cable material represents less than 5 percent of the total project costs, installing incremental fiber optic strand capacity at the time of new construction allows spare strand capacity. The spare strand capacity could be allocated for future local and regional transportation needs or used as dark fiber available for sharing among other public agencies through CTIC.

7.2 Regional Priority TransPort Projects

Table 1 identifies the top priority projects for the TransPort group. Numbering is for identification purposes only and does not represent relative priority. Please refer to Appendix A for maps that show these projects.

7.3 Local Agency Priority Projects

Table 2 describes priority projects for local agencies. These are projects that are critical for individual agencies and are typically within a single agency's jurisdiction. Because these projects are isolated to single agencies they are categorized as local agency priority projects and not regional priority projects that aim to expand interagency communications. Letters are for identification purposes only and do not represent relative priority. Please refer to Appendix A for maps that show these projects.

Table 3 describes priority projects for TriMet. These projects include connecting stations along the WES commuter rail line to fiber communications as well as bridging some gaps in the Rose Quarter and Gateway areas. Lettering is for identification purposes only and does not represent relative priority. Please refer to Appendix A for maps that visually describe these projects.

Table 1: Regional Priority TransPort Projects

ID*	Project Name	Map	Agency	Description and Extents	Regional Significance	Dist. (miles)	Existing Copper or Conduit	Construction Type	Estimated Costs ($M)
1	Tualatin Valley Highway	1, 3	ODOT, Hillsboro, Beaverton, Washington County & TriMet	From OR 217 in Beaverton to Oak Street in the City of Hillsboro	Connects local infrastructure directly. Serves as a backbone. Creates regional redundancy and reliability.	9.5	Partially	Urban	$0.9 to $2.35**
2	Columbia Boulevard	1, 3, 5	City of Portland	North side City of Portland from west end of Columbia Boulevard at Burgard Road to I-205	Provides communications along a key freight facility that runs between I-205 and I-5	10.4	Partially	Urban	$3.12
3	US 26 and MAX Tunnels	1, 7	ODOT & TriMet	West of Portland downtown through tunnels on US 26 for vehicle traffic and MAX trains	Solves two key regional bottleneck/gap	3.0	Partially	Tunnel	$0.60
4	Division Street	1, 5, 6	City of Portland & TriMet	From SE 21st Avenue to SE 112th Avenue	Bus Rapid Transit (BRT) is planned for Division Street and communication upgrades are necessary to support the BRT project	4.7	Partially	Urban	$1.41
5	Powell Boulevard	1, 5, 6	City of Portland, ODOT, & City of Gresham	From SE 112th Avenue in the City of Portland to Hogan Drive in the City of Gresham	Adds communications along a key regional arterial connecting Portland to Gresham along an ODOT facility	6.8	Partially	Urban	$2.04

6	Barbur Boulevard (Bottleneck)	1, 6, 7	ODOT	From 4th Avenue (downtown) to Terwilliger Boulevard.	Solves a key regional bottleneck	3.1	Partially	Aerial	62
7	OR 99W (North Segment)	1, 3	ODOT	Multnomah Boulevard to I-5	Adds communications along a key arterial adjacent to I-5; Ideal location for integrated corridor management (ICM)	2.8	No	Urban	$0.84
8	OR 99W (South Segment)	1, 4	ODOT, Washington County, Tigard, TriMet	OR 217 to Tualatin-Sherwood Road	Connects local infrastructure directly. Serves as a backbone. Creates regional redundancy and reliability.	6.4	Partially	Urban	$1.92
	TOTALS					**46.7**			**$11.45 - $12.90**

* Numbering is for identification purposes only and does not represent relative priority

**Cost determined as part of the TIGER ATM project. Low cost assumes existing aerial path will be maintained. High cost assumes relocation of existing aerial to new underground path.

Table 2: Local Agency Priority Projects

ID*	Project Name	Map	Agency	Description and Extents	Significance	Dist. (miles)	Existing Copper or Conduit	Construction Type	Estimated Costs ($M)
A	Beaverton Hillsdale Highway	1, 3	Cities of Beaverton & Portland	From Barbur Boulevard to downtown Beaverton	Key arterial	5.9	Partially	Urban	$1.77
B	Sandy Boulevard	1, 5	City of Portland, Gresham, & Multnomah County	From Stark Street to NE 238th Avenue	Upgrades communications along a key arterial, and creates ICM opportunities with I-84 east of I-205	12.3	Partially	Urban	$3.69
C	Halsey Street	1, 5	City of Portland	I-205 to 181st Avenue	Creates ICM opportunities with I-84	4.2	Partially	Urban	$1.26
D	Stark Street	1, 5	Cities of Portland & Gresham	From I-205 to Hogan Drive	Creates ICM opportunities with I-84	7.4	Partially	Urban	$2.22
E	181st Avenue	1, 5	City of Gresham	From Sandy Boulevard to Burnside Street	Upgrades communications along a key arterial	1.7	Partially	Urban	$0. 51
F	Oatfield Road	1, 6	Clackamas County	Lake Road (near OR 99E, north end) to 82nd Drive (south end)	Runs adjacent to OR 99E; Upgrades communications along a key arterial	4.2	Partially	Urban	$1.26

ID*	Project Name	Map	Agency	Description and Extents	Significance	Dist. (miles)	Existing Copper or Conduit	Construction Type	Estimated Costs ($M)
G	Macadam Avenue	1, 6	ODOT	Hood Avenue to south of the Sellwood Bridge	Upgrades communications along a high capacity arterial that connects downtown Portland to areas south	2.8	Partially	Urban	$0.84
	TOTALS					**38.5**			**$11.55**

*** Lettering is for identification purposes only and does not represent relative priority**

Table 3: TriMet Priority Projects – Local Connections and WES Station Connections

ID*	Project Name	Map	Agency	Description	Significance	Distance (miles)	Existing Copper or Conduit	Construction Type	Estimated Costs ($M)
H	Rose Quarter Area	1, 7	TriMet, City of Portland	Local Interconnection	Connects TriMet and City of Portland fiber	minimal	No	Urban	S0.10
I	Gateway Area	1, 5	TriMet, ODOT	Local Interconnection	Connects TriMet and ODOT fiber	minimal	No	Urban	S0.10
J	Beaverton Transit Center	1, 3	TriMet	WES station connection	Connects a TriMet station to fiber communications	minimal	No	Urban	S0.10
K	Hall/ Nimbus	1, 3, 4	TriMet	WES station connection	Connects a TriMet station to fiber communications	minimal	No	Urban	S0.10
L	Tigard Transit Center	1, 3, 4, 6	TriMet	WES station connection	Connects a TriMet station to fiber communications	minimal	No	Urban	S0.10

ID*	Project Name	Map	Agency	Description	Significance	Distance (miles)	Existing Copper or Conduit	Construction Type	Estimated Costs ($M)
M	Tualatin	1, 4	TriMet	WES station connection	Connects a TriMet station to fiber communications	minimal	No	Urban	$0.10
N	Wilsonville	1, 4	TriMet	WES station connection	Connects a TriMet station to fiber communications	minimal	No	Urban	$0.10
	TOTAL								**$0.70**

*** Lettering is for identification purposes only and does not represent relative priority**

APPENDIX A MAPS

List of Maps

DKS | IBI

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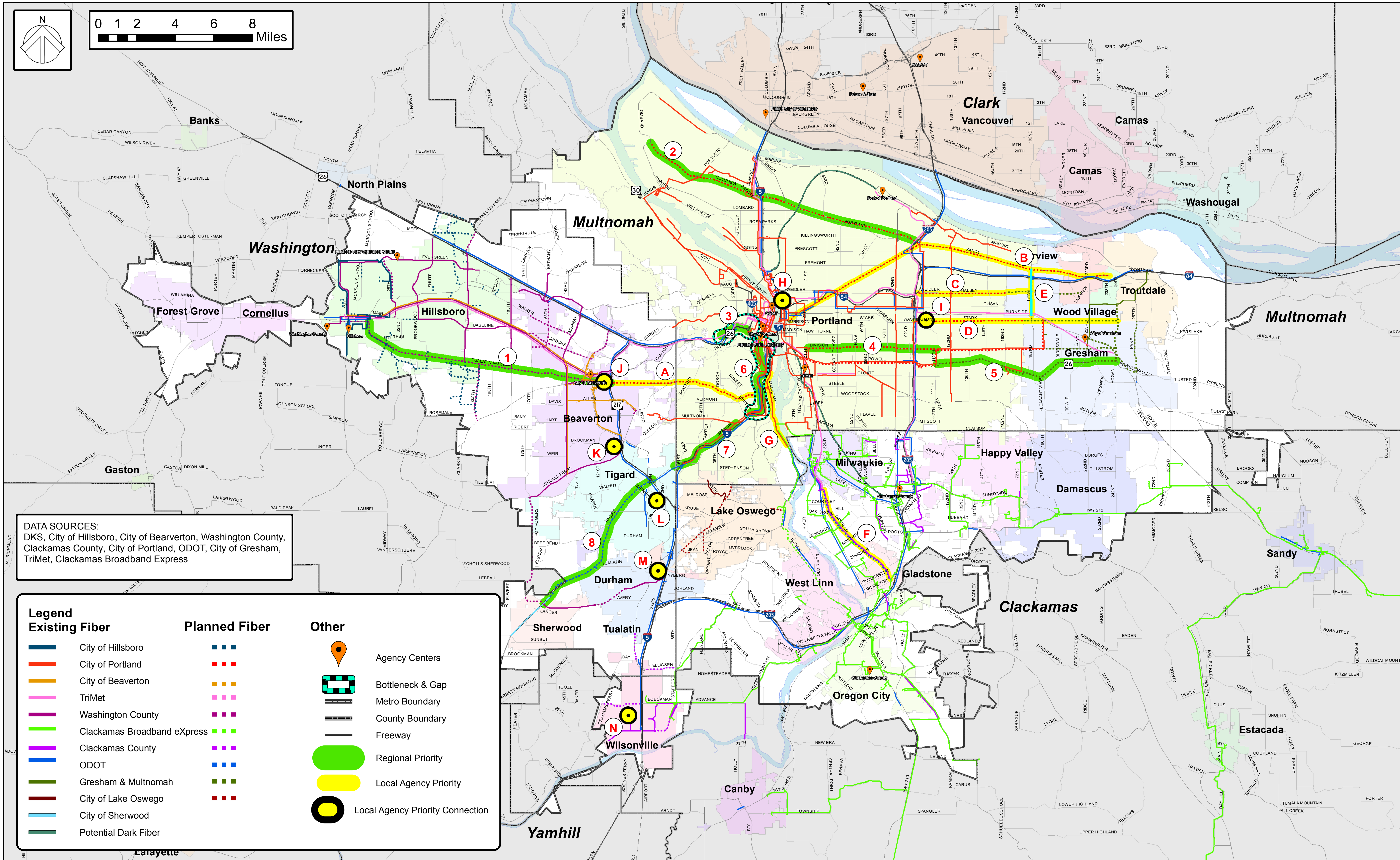
500 – Meredith Block,
611 Meredith Road NE
Calgary AB T2E 2W5 Canada
tel 403 270 5600 fax 403 270 5610

METRO AREA COMMUNICATIONS INFRASTRUCTURE

MAP 1: EXISTING & PLANNED FIBER OPTIC CABLE PORTLAND METRO REGION



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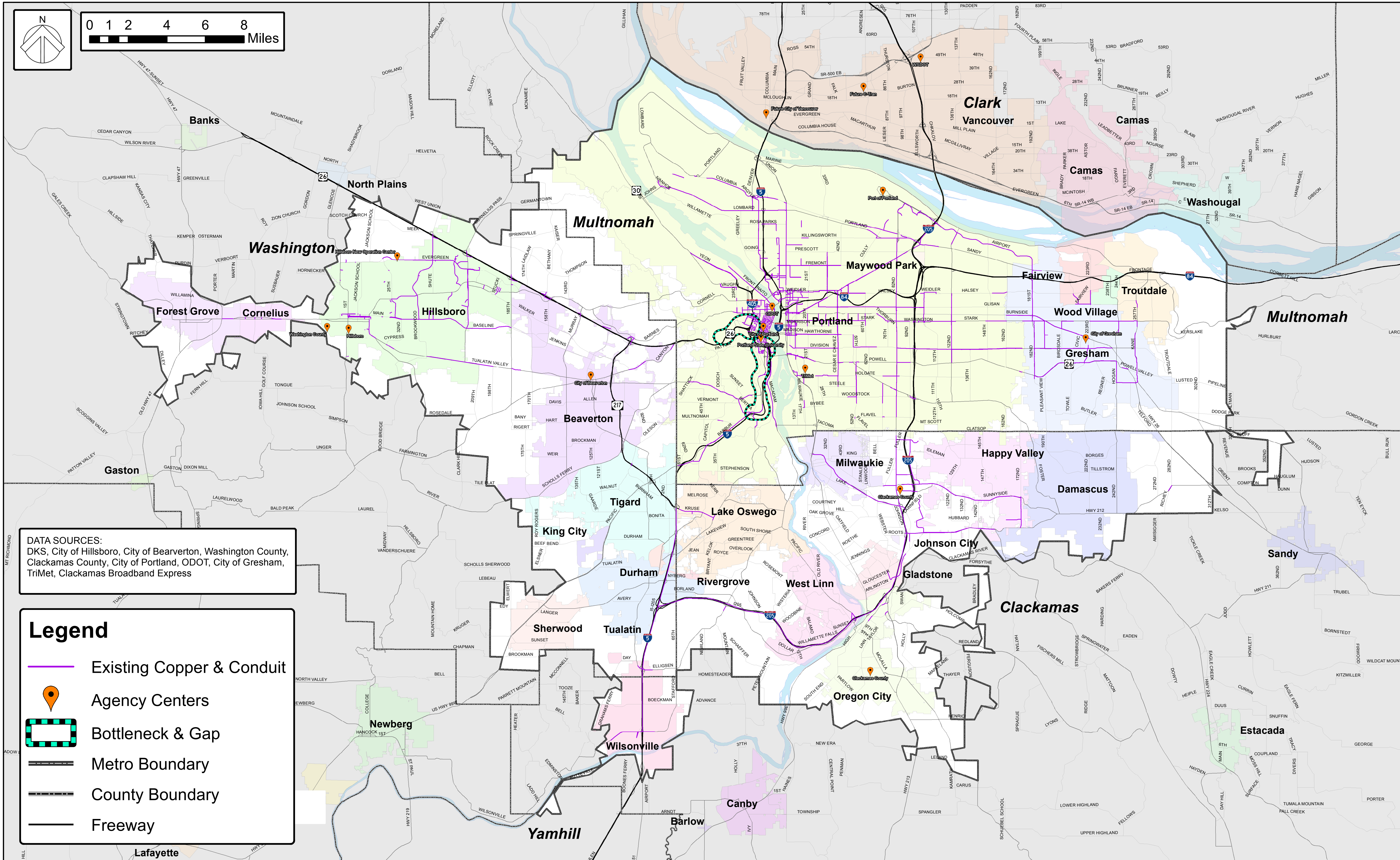
METRO AREA COMMUNICATIONS INFRASTRUCTURE

MAP 2: EXISTING COPPER CABLE & CONDUIT - PORTLAND METRO REGION REGION



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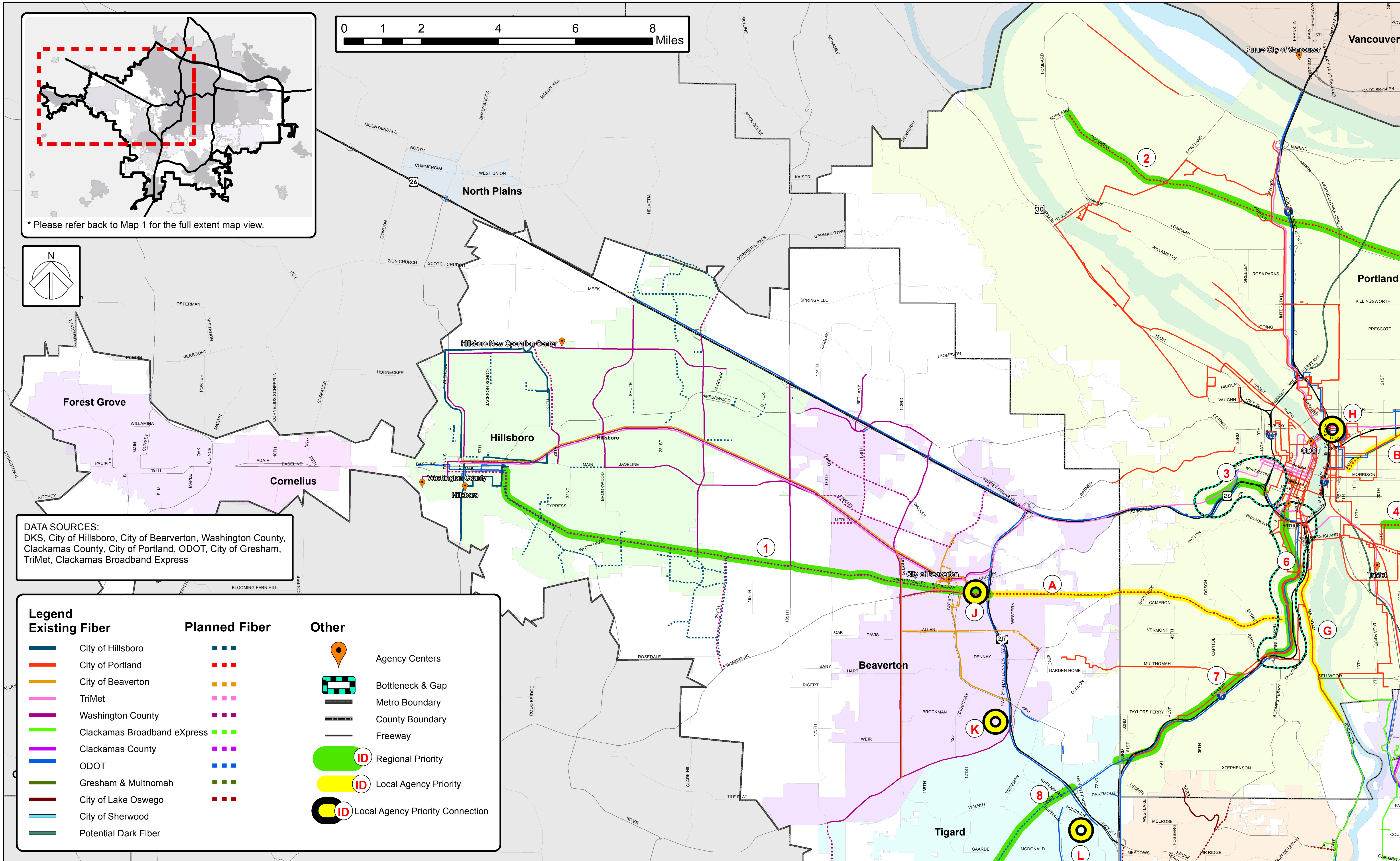
METRO AREA COMMUNICATIONS INFRASTRUCTURE

MAP 3: EXISTING & PLANNED FIBER OPTIC CABLE - PORTLAND METRO REGION NORTH WEST



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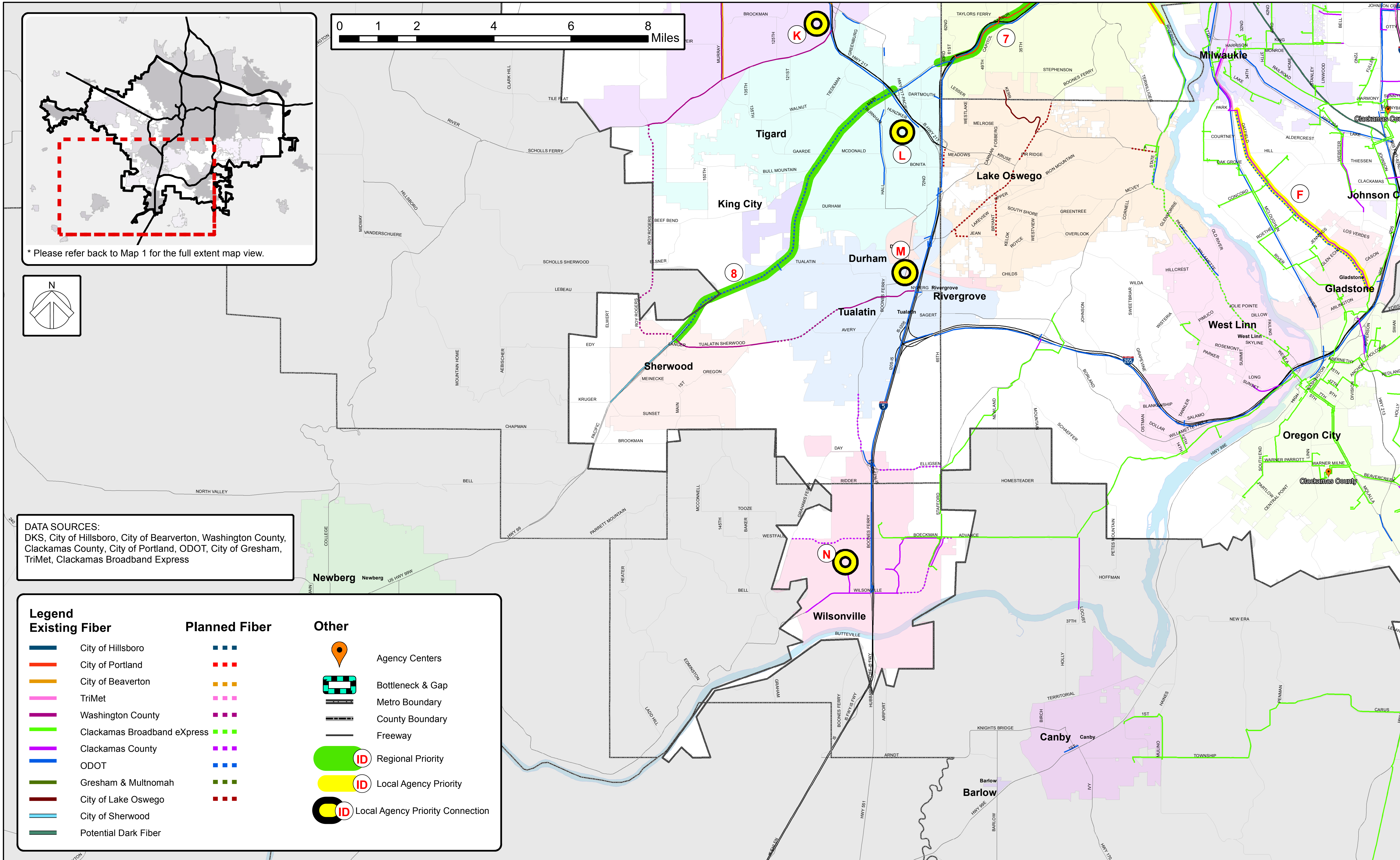
METRO AREA COMMUNICATIONS INFRASTRUCTURE

MAP 4:EXISTING & PLANNED FIBER OPTIC CABLE - PORTLAND METRO REGION SOUTH WEST



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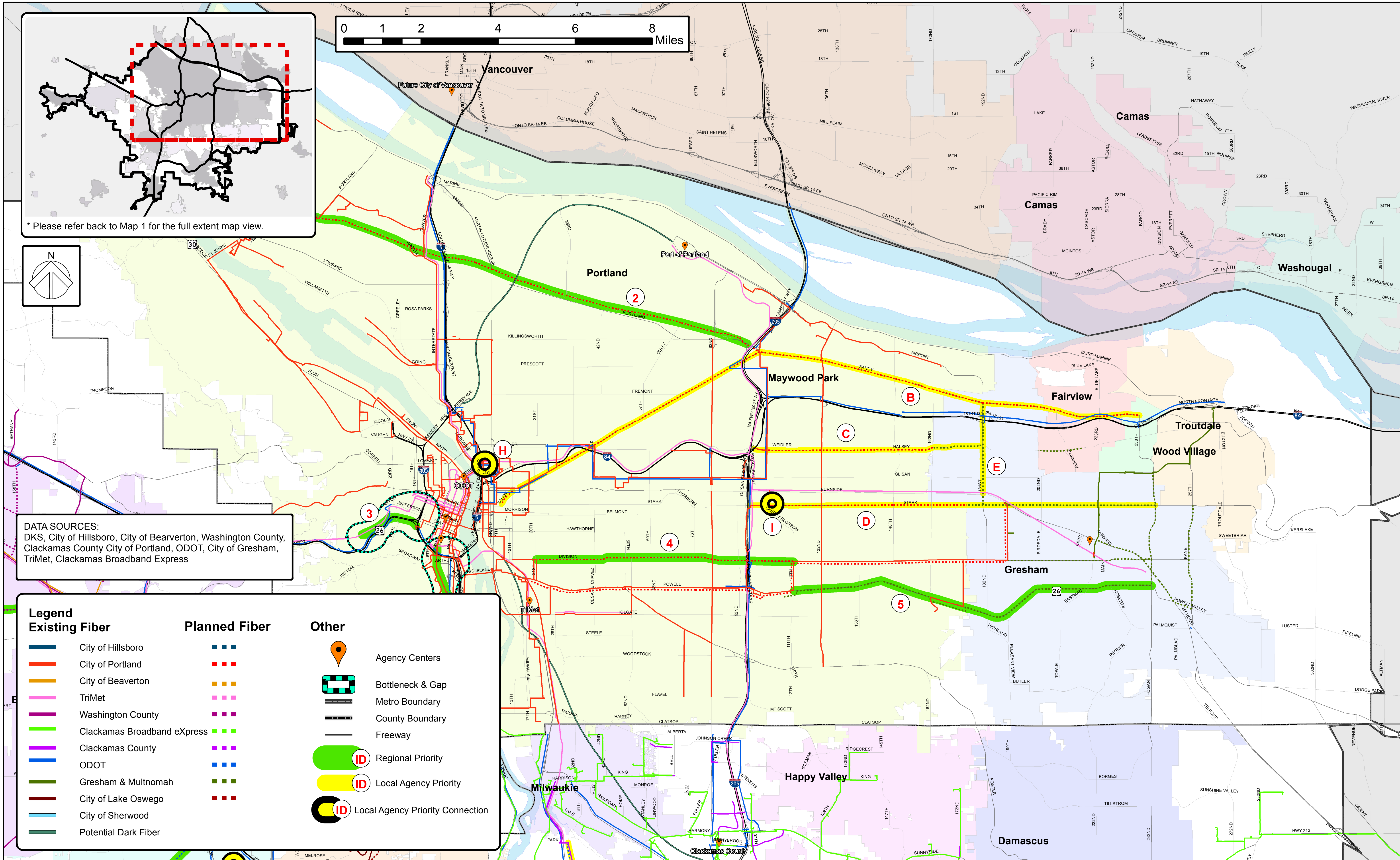
METRO AREA COMMUNICATIONS INFRASTRUCTURE

MAP 5: EXISTING & PLANNED FIBER OPTIC CABLE -PORTLAND METRO REGION NORTH EAST



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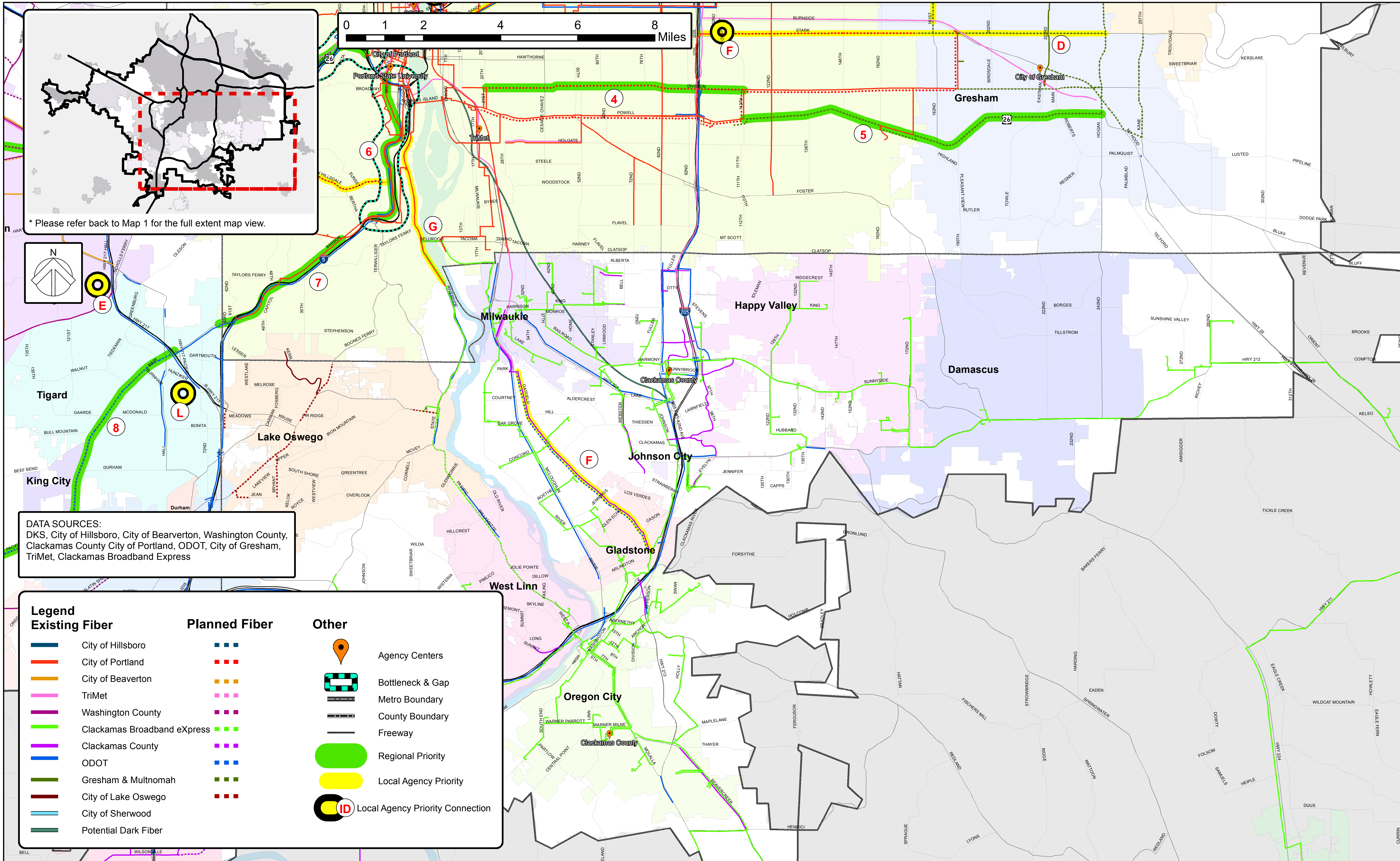
METRO AREA COMMUNICATIONS INFRASTRUCTURE

MAP 6: EXISTING & PLANNED FIBER OPTIC CABLE - PORTLAND METRO REGION NORTH EAST



APPENDIX B CTIC AND ITS NETWORK GUIDELINES AND POLICIES

ITS Transport Network
Core Connection
Memorandum of Understanding

A. General

The ITS Transport Network (hereinafter referred to as “ITS network”) is managed and operated by a collaborative group of authorized representatives from each agency connected to the ITS network. This group is referred to as the ITS Network Management Team (ITS-NMT). The ITS-NMT is an authorized perpetual sub-committee of the TransPort TAC.

This Memorandum of Understanding (MOU) describes the expectations of the ITS-NMT and agencies connected as core members to the ITS network. It defines the agency’s service level expectations for network services provided by the ITS-NMT, and expectations the ITS-NMT members have of the undersigned agency (hereinafter referred to as “Agency”).

Failure of an agency to provide the described resources and comply with ITS-NMT’s policies, procedures, and connection requirements will be addressed on a case-by-case basis. For the protection of all agencies participating in the ITS network, possible consequences may range from a warning to removal of the Agency’s ITS network connection until the failure has been resolved.

Agency Name:	
ITS Network Management Team Representative	
Primary:	Secondary:

B. Acceptable Use of the ITS Network

As stated in the ITS Transport TAC Policy #2005-01, “The ITS network must only be used by public agencies for the purpose of transmitting transportation-related information defined in Transport’s regional ITS architecture. Private entities cannot directly connect to the network or directly transmit any information through the network. Agencies connected to the network are responsible for insuring that information they transmit through the network has been pre-authorized as an acceptable data flow.” Requests to add new types of information onto the ITS network will be submitted to the ITS-NMT by the Agency’s ITS-NMT member.

C. Participation in Transport TAC

The ITS network is a resource created by the TransPort TAC, for use by TAC members. Agencies connected to the ITS network must participate in the TransPort TAC, to insure that each agency on the network is represented during discussions and decisions relating to policies and the use of the ITS network.

D. Security
Each agency will retain control of, and thereby be solely responsible for, their network security via their firewall configurations and anti-virus solutions.

E. ITS Network Management Team Committed Service Level
The ITS network will be operated seven days a week, 24 hours per day, for 365 days per year. Based upon agency requirements to only provide "best effort" service responses, the ITS-NMT will attempt to have service disruptions (planned and unplanned) not exceed 1% (87.6 hours) during any one-year period. Agencies will be notified of planned service disruptions seven (7) days in advance.

F. Agency Requirements

1. **Staff resources**
   The Agency will provide perpetual staff resources to perform two roles. At the Agency's discretion, these resources may be the same or a variety of individuals, based upon the Agency's organizational structure and requirements of the representatives. The two roles are as follows:
   a. At least one primary representative (and preferably a secondary representative) to participate as a member of the ITS-NMT.
   b. A representative must participate in the Transport TAC on a regular basis.

2. **ITS Network Management Team member functions**
   a. Participation in team activities, including participation in team meetings and performing daily operation of the ITS network.
   b. In the event of a network failure, representatives agree to respond to the failure on a "best effort" basis.
   c. Coordinate the collection of their agency configuration documents as required by the ITS-NMT.
   d. Insure they have appropriate contacts within their agency for resolving firewall configuration problems.
   e. Communicate network activities that may potentially impact their agency.
   f. Communicate all ITS network policies and procedures to their agency, and insure compliance.
   g. Insure appropriate service contracts and replacement funding is obtained to service the agency's ITS network connection equipment.

3. **Budget resources.**
   On a cyclical basis, all ITS network components will need to be replaced to insure the stability and functionality of the network. The ITS-NMT will determine the replacement cycle of all network components (estimated at every six years). The ITS-NMT will notify the undersigned agency, in writing, at least one (1) year prior to the replacement period. When replacement is required, the undersigned agency will provide for a replacement budget for the ITS network connection equipment located at their location. If budget is not available for the replacement period, upon replacement of all ITS network components the undersigned agency's network connection will be disconnected.

4. **Network requirements.**
   The following components must be in use and up-to-date at all times within the Agency’s internal network.
   a. An enterprise-class firewall solution (not a personal firewall) that supports stateful packet inspection and is capable of performing Network Address Translation (NAT). Port Address Translation (PAT) is not required. All connections to the ITS network switch equipment will be terminated in a firewall.

   b. An enterprise-class Anti-Virus software used on Microsoft Windows Operating System host devices connecting to the ITS network. Windows hosts must receive auto updates of virus signatures. Host devices with Operating Systems other than Windows that are connecting to the ITS network must have current patch releases installed at all times. Agency will provide documentation of their current Anti-Virus update schedule and patch management practices.

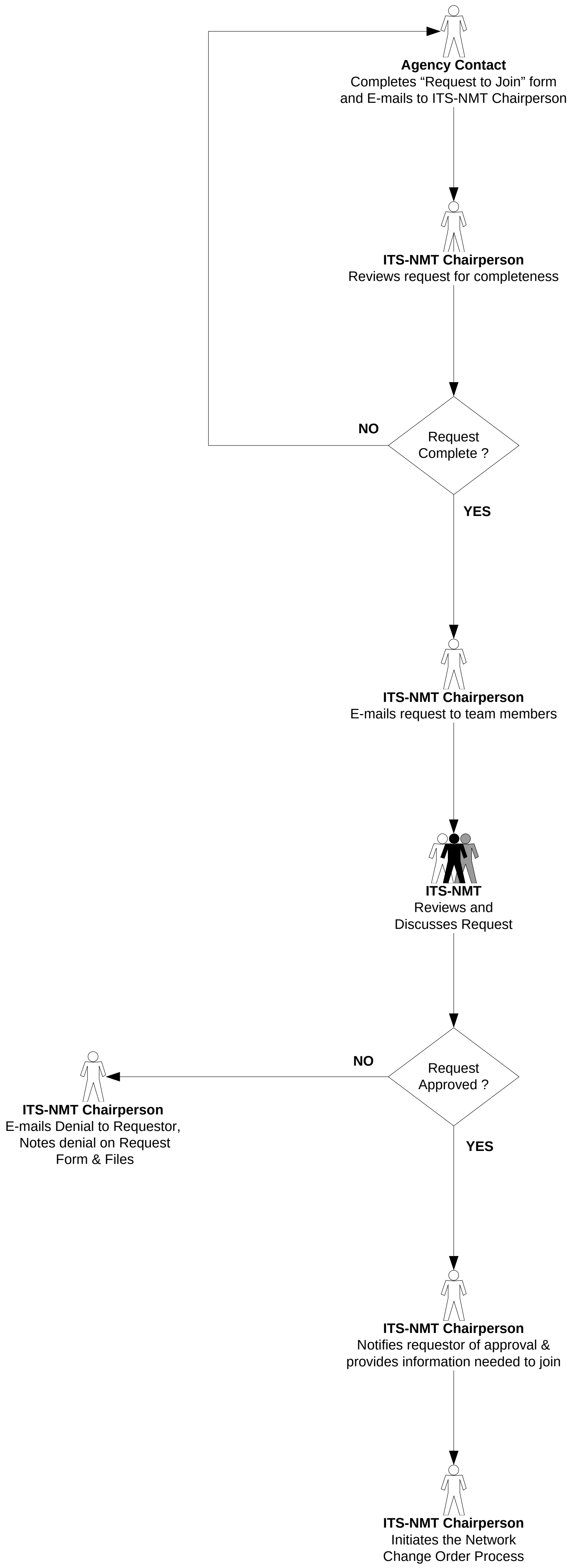
Goals of this Memorandum of Understanding (MOU)
The intention is to form a perpetually operating network with continued agreements with each participating agency. However, due to changing budget conditions and business operation needs, this MOU shall have a termination date of July 1, 2010 or the date the undersigned agency ceases to connect to the ITS network (whichever comes first). On January 1, 2010 the ITS Network Management Team and the undersigned agency will engage in a process to establish a new MOU for the next five (5) year period. If a new MOU is not enacted prior to July 1, 2010, the undersigned agency will be disconnected from the ITS network. The ITS Network Management Team shall provide written notification of their intent to disconnect services 60 days prior to service termination.

[Agency Name]	ITS Network Management Team
Print Name:	Print Name:
Signature:	Signature:
Date:	Date:

ITS Network
Request to Join the Network
Process Overview

Legend

ITS-NMT = ITS Network Management Team



Filename: ITS Network - Request to Join Network - Process Overview.vsd
Edit Date: 6/14/2006 RLW

APPENDIX C STAKEHOLDER WORKSHOP ATTENDEES

Stakeholders

- Jabra Khasho (City of Beaverton)
- Tina Nguyen (City of Beaverton)
- Chris Strong (City of Gresham)
- Tegan Enloe (City of Hillsboro)
- Willie Rotich (City of Portland)
- Mike Ward (City of Wilsonville)
- Bikram Raghubansh (Clackamas County)
- Orlena Chiu (DEA)
- Nathaniel Price (Federal Highway Administration)
- Shaun Quayle (Kittelson and Associates)
- Caleb Winter (Metro)
- Aszita Mansor (Multnomah County)
- Mike Burkart (ODOT)
- Andrew Dick (ODOT)
- Dennis Mitchell (ODOT)
- Ryan Williams (WSP Parsons Brinckerhoff)
- Kristin Tufte (Portland State University)
- Bob Hart (Southwest Washington Regional Transportation Council)
- Ron White (TriMet)
- Stacy Shetler (Washington County)
- Stan Markuson (Washington State DOT)

Consultant Team

- Bruno Peters (IBI Group)
- Keith Ponton (IBI Group)
- Mike Haas (IBI Group)
- Jennifer Bachman (DKS Associates)
- Jim Peters (DKS Associates)
- Adrian Pearmine (DKS Associates)