

Non-potable Water Reuse Analysis

September 3, 2020

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FINAL DRAFT

Non-potable Water Reuse Analysis

Technical Memorandum

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Abbreviations

CCF	Centum Cubic Feet
City	City of Seattle
DWW	Drainage and Wastewater
EPA	United States Environmental Protection Agency
GIS	Geographic information system
ISP	Integrated System Plan
LOB	Line of Business
SPU	Seattle Public Utilities
TM	Technical Memorandum

1. Introduction

To support the development of the Integrated System Plan (ISP), this technical memorandum (TM) summarizes the geospatial analysis conducted to identify areas with a high potential demand for non-potable water within the City of Seattle. The GIS datasets developed as a result of this analysis indicate potential areas of opportunity to explore cost effective, district scale non-potable reuse systems in the ISP.

1.1 Objective

The goal of this analysis is to identify which areas of the city show the greatest potential demand for non-potable water. Blocks or neighborhoods with relatively high concentrations of non-potable demand may indicate potential opportunities to explore non-potable reuse systems at the district scale. Non-potable reuse systems utilize alternate water sources for end uses that do not require potable water, such as toilet flushing, irrigation, cooling/heating, industrial processes, etc. Water reuse systems can provide multiple benefits for the communities they serve, such as improving system resilience to service disruptions as a result of seismic or climate change impacts, diversifying water supply, increasing infrastructure capacity, deferring capital costs, reducing the volume of wastewater requiring treatment, decreasing receiving waterbody pollution, conserving potable water, providing cost savings for water customers, and generating co-benefits (National Blue Ribbon Commission for Onsite Non-potable Water Systems, 2018). While non-potable reuse systems can be implemented at the building or parcel scale, identifying opportunities for non-potable reuse systems across multiple properties (or at the 'district scale') was the focus of this analysis.

Potential non-potable demand was assessed though geospatial analysis to create two citywide GIS layers:

1. Intensive Water Consumers: Identification and creation of an Intensive Water Users layer displaying the top 2% of the City's most intensive water consumers
2. High Potential by Land Use: Identification and mapping of land uses likely to have significant non-potable water demand

When displayed together, "Intensive Water Consumers" and "High Potential by Land Use" show the spatial distribution of the City's intensive water consumers and those with significant non-potable water demand and reveal clusters of parcels that may have greater potential for utilizing district scale non-potable reuse systems. This analysis does not assess potential sources (i.e. supply) of non-potable water, feasibility of district scale non-potable reuse systems, or potential non-potable demand at the individual parcel scale.

1.2 Source Data

Table 1 displays the datasets utilized to conduct this analysis. The accuracy of the GIS layers created from this analysis depend entirely on the accuracy of the source datasets.

Table 1. Source Data		
Dataset:	**Date accessed/received:**	**Sourced from:**
Existing Land Use – 20 Categories	12/4/2019	City of Seattle GIS
Top 10 percent City of Seattle Water Customers for the year 2019	1/15/2020	Doug Ricker, SPU Water Line of Business (LOB)

2. Methods

The identification of areas with high potential to utilize non-potable reuse systems was completed through a combination of two analyses. The first, which identified "intensive water consumers" within the City of Seattle, is described in section 2.1. The second analysis identified parcels of "high potential by land use" and is described in section 2.2.

2.1 Intensive Water Consumers

The first major component of this analysis identified Seattle water consumers with significant water demand. A dataset comprising the top 10% of City of Seattle water consumers for the year 2019 was received from SPU's Water LOB on 1/15/2020. Address information from the Water LOB dataset was geocoded, meaning that addresses were converted to latitude/longitude coordinates that allow the data to be projected in GIS. The geocoding process revealed that a significant number of intensive water consumer data points corresponded with single-family zoned parcels. However, for this analysis, district scale non-potable reuse systems are assumed to be non-feasible in single-family areas, therefore parcels within single-family zoning were removed from the dataset. Annual water usage of those single-family zoned parcels was found to always be less than or equal to 1,000 centum cubic feet (CCF) per year. Therefore, 1,000 CCF per year was identified as the appropriate threshold for intensive water customers in other zoned parcels. Any intensive water consumers using less than or equal to 1,000 CCF per year were eliminated from the Water LOB dataset. The resulting dataset includes the top 2% of City of Seattle water consumers.

Next, the geocoded water consumer data was combined with "Existing Land Use – 20 Categories" using the GIS spatial join tool. This resulted in the creation of a new GIS layer, "Intensive Water Consumers", that includes all attributes of the "Existing Land Use – 20 Categories" layer with the intensive water consumer data associated with individual parcels.

2.2 High Potential by Land Use

The second major component of this analysis identified locations where land use may indicate a significant non-potable share of total water demand, or, in other words, where the higher potential exists to replace potable water demand with non-potable water. Types of water demand that could be met using non-potable water include toilet flushing, irrigation, industrial process water, cooling/heating water, etc.

Land use types were determined based on the City of Seattle dataset "Existing Land Use – 20 Categories." When possible, potential high non-potable demand was determined based on US EPA estimates of typical water end uses. In some cases, only a subset of a land use category was determined to be high (section

2.2.1). When the City of Seattle land use categories were not covered by the US EPA land use categories, alternative data sources or case studies were used to determine if potential non-potable demand was high (section 2.2.2).

In general, land uses that have balanced water use between non-potable demand and non-potable supply result in the largest estimated potential water savings (Vandegrift, 2014). For this analysis, any land use with at least 40% of its total water demand originating from uses that could be replaced with non-potable water was designated as having "high" potential demand. Less than 40% was considered low potential demand. Forty percent was identified as the appropriate threshold between high potential and low potential demand because some land uses – for example, hotels/motels – have 40% of their water use originating from uses that could be replaced with non-potable water, which means water use in hotels/motels is nearly balanced. If 50% were used as the threshold instead, the potential of hotels/motels to use non-potable water would not have been captured by this analysis. Parcels within "high" demand land uses were included in a new GIS layer, "High Potential by Land Use."

2.2.1 Non-Potable Demand Based on US EPA Typical Water End Use

The US EPA provides estimates of typical water end uses for select land use categories, such as office buildings, educational facilities, hotels, restaurants, and hospitals, (EPA, 2019). US EPA estimates of typical water end uses were used to designate high or low non-potable demand for the following 7 of the 20 City of Seattle existing land use categories:

- Schools
- Mixed-Use
- Multi Family
- Other Housing
- Office
- Hotel/Motel
- Institutions (Hospitals only)

End uses of water vary by land use category, but typically include estimates of how much water is used for restrooms, kitchens, laundry, cooling/heating, landscaping, etc. as a percentage of total water use, as shown in Figure 1.

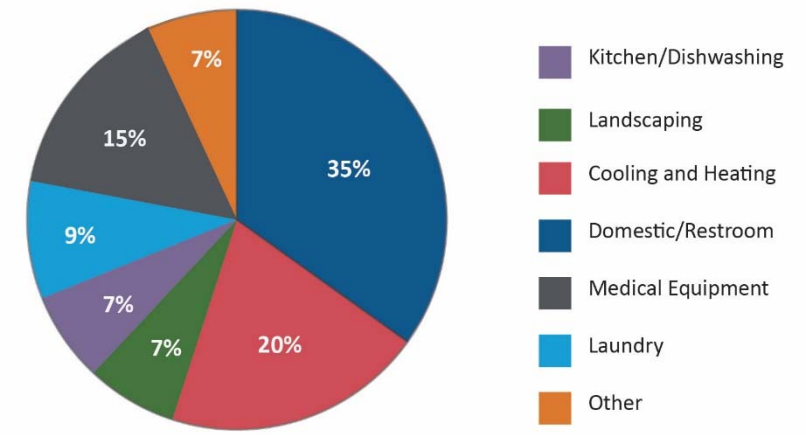

Figure 1. Example of typical water end uses for Hospitals provided by EPA.

Based on these estimations, each type of water end use was categorized as either a use that could be replaced with non-potable water (such as Landscaping), or a use that requires potable water (such as Kitchen/Dishwashing). Figure 2 shows end uses of water in hospitals categorized by whether each use has the potential to utilize non-potable water, or if it requires potable water.

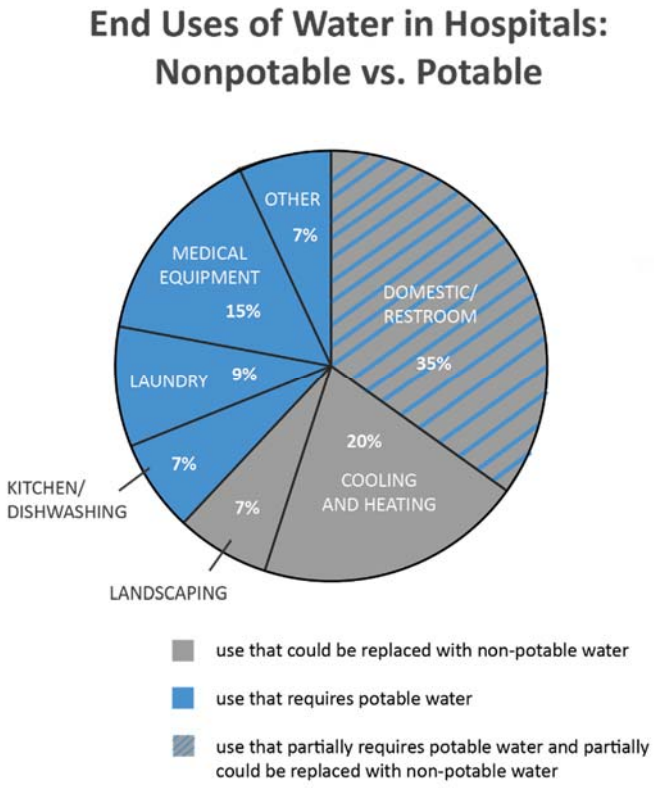

Figure 2. End Uses of Water in Hospitals: Potable vs Non-potable.

Typical estimates for school, hospital, office, and hotel/motel land use categories group domestic/restroom water end uses together, which does not capture that toilets in those land use categories can use non-potable water. However, typical estimates of how water is used in restrooms for residential land uses break out showers, sinks, and toilets separately (EPA, 2019). In order to ensure that the potential for toilets to be flushed with non-potable water was captured for school, hospital, office, and hotel/motel land use categories, typical estimates of how water is used in the restrooms of residential land uses were utilized to make an assumption about how water is used in the restrooms of those land use categories.

For residential land uses, toilets are estimated to be 12% of total water demand and bathroom sinks are estimated to be 9.5% of total water demand (EPA, 2019). The ratio of 9.5:12 was utilized to estimate what portion of domestic/restroom water demand should be considered non-potable vs. potable in the school, hospital, and office land use categories. Table 2 shows the resulting estimated non-potable vs. potable water demand for domestic/restroom end uses for each of the school, hospital, and office use categories.

Table 2. Estimated Non-potable vs. potable water demand for domestic/restroom end uses per land use category

Land Use Category	Total domestic/restroom demand as percentage of overall water demand	Non-potable water demand (toilets) as percentage of total domestic/restroom demand	Potable water demand (sinks) as percentage of total domestic/restroom demand
Office	37%	20.7%	16.3%
School	45%	25.2%	19.8%
Hospital	35%	19.6%	15.4%

Estimates of water demand from showers as a percentage of total domestic/restroom water demand was not included for office, school, or hospital land use categories because it is assumed to be unlikely that offices, schools, or hospitals use an amount of water for showers that is comparable to that of a residential building.

However, estimates of water demand from showers as a percentage of total domestic/restroom water demand were included for the hotel/motel land use category because the typical hotel/motel room includes a shower. For residential land uses, showers are estimated to account for 10.2% of total water demand (EPA, 2019). With showers included, the ratio of potable water demand (sink and shower) to non-potable water demand (toilets) for domestic/restroom uses is 19.7:12. The ratio of 19.7:12 was utilized to estimate what portion of domestic/restroom water demand should be considered non-potable vs. potable in the hotel/motel land use category. Table 3 shows the resulting estimated non-potable vs. potable water demand for domestic/restroom end uses for the hotel/motel land use category.

Table 3. Estimated Non-potable vs. potable water demand for domestic/restroom end uses for hotel/motel land use category			
Land Use Category	**Total domestic/restroom demand as percentage of overall water demand**	**Non-potable water demand (toilets) as percentage of total domestic/restroom demand**	**Potable water demand (sinks and showers) as percentage of total domestic/restroom demand**
Hotel/motel	30%	11.4%	18.6%

The estimated non-potable water demand based on the available EPA water end use estimates for 7 land use categories, with modifications to the domestic/restroom end uses incorporated, are described below.

Schools

The estimated non-potable demand for the Schools land use category was calculated based on the EPA water end use estimates for educational facilities. Table 5 shows how estimated non-potable demand was calculated based on the EPA water end use estimates, with toilets, cooling/heating, and outdoor/landscaping categories contributing to estimated total non-potable demand. (See Table 2 for more information on how toilet and sink estimates were calculated).

Table 4. Estimated non-potable demand based on EPA end use estimates: Schools	
End Water Use	**% of total water demand**
Kitchen/Dishwashing	7
Outdoor/Landscaping	28
Cooling/Heating	11
Toilets	25.2
Sinks	19.8
Laundry	3
Pools	1
Other	5
Total estimated non-potable demand	**64.2**

For the remaining 6 land use categories, not every parcel within those categories was likely to have high non-potable demand. Therefore, only a selection from each of the remaining 6 land use categories were determined to have high potential demand. The assumptions made regarding the potential demand for the 6 land use categories are detailed below.

"Mixed Use," "Multi-Family," and "Other Housing"

The following assumptions regarding the potential for Mixed-Use, Multi-Family, and Other Housing parcels to utilize non-potable reuse systems were made for this analysis:

1. Mixed-Use, Multi-Family, and Other Housing parcels have end use water breakdowns similar to that of a single-family parcels, but the volume used is likely orders of magnitude greater than that of a single-family parcel.
2. The volume of water used in a Mixed-Use, Multi-Family, or Other Housing parcel is a function of the number of dwelling units on that parcel.
3. Mixed-Use, Multi-Family, and Other Housing parcels that use a volume of water comparable to that of a single-family parcel in Seattle (i.e., less than or equal to 1000 CCF per year) are not considered high potential.

The estimated non-potable demand for Mixed-Use, Multi-Family, and Other Housing land use categories was calculated based on the EPA water end use estimates for residential land uses. Table 6 shows how estimated non-potable demand was calculated based on the EPA water end use estimates, with toilet and outdoor/landscaping categories contributing to estimated total non-potable demand.

Table 5. Estimated non-potable demand based on EPA end use estimates: Mixed-Use, Multi-Family, Other Housing

End Use	% of total water demand
Toilets	12
Showers	10.2
Faucets	9.5
Clothing Washers	8.2
Baths	1.3
Dishwasher	0.6
Outdoor/Landscaping	50.1
Leaks	6.2
Other	1.9
Total estimated non-potable demand	**62.1**

The Mixed-Use, Multi-Family, and Other Housing land use categories required modifications in order to more accurately reflect non-potable water demand because not all parcels in those land use categories were likely to have high non-potable demand.

To determine which parcels within Mixed-Use, Multi-Family, and Other Housing land use categories should be considered as having significant non-potable water demand, "Intensive Water Consumers" data was cross-referenced with all parcels in these categories to determine the average number of units contained on parcels that use over 1000 CCF of water per year. Based on this review, it was determined that any given Mixed-Use, Multi-Family, or Other Housing parcel must have 50 or more units to be considered as having high potential to utilize non-potable reuse systems.

Office

The estimated non-potable demand for the Office land use category was calculated based on the EPA water end use estimates for office buildings. Table 7 shows how estimated non-potable demand was calculated based on the EPA water end use estimates, with toilet, cooling/heating, and outdoor/landscaping categories contributing to estimated total non-potable demand. (See Table 2 for more information on how toilet and sink estimates were calculated).

Table 6. Estimated non-potable demand based on EPA end use estimates: Offices

End Use	% of total water demand
Kitchen/Dishwashing	13
Outdoor/Landscaping	22
Cooling/Heating	28
Toilets	20.6
Sinks	16.4
Total estimated non-potable demand	**70.6**

The Office land use category required modifications in order to more accurately reflect non-potable water demand because not all parcels in those land use categories were likely to have high non-potable demand. Non-potable water demand comprises 70.6% of total water demand in office buildings (EPA, 2019). However, the majority of this non-potable water demand consists of the water used by building cooling/heating processes and irrigation for landscaping. Therefore, if a given office parcel does not have either cooling towers or large landscaping requiring irrigation, it would not have nearly as high of a non-potable water demand as an office parcel that does. To determine which office parcels should be considered as having significant non-potable water demand, a manual scan for office parcels with visible cooling towers and/or landscaping was done using satellite imagery in GIS. The attributes of office parcels with cooling towers and/or landscaping were then analyzed for commonalities from which an assumption about non-potable water demand could be generated. Based on a review of the range of number of stories and lot sizes for office buildings that include cooling towers and/or landscaping, it was determined that any given office parcel must either have a lot size that is greater than 10,000 square feet or be more than four stories high in order to be considered as having high non-potable potential.

Hotel/Motel

The estimated non-potable demand for the Hotel/Motel land use category was calculated based on the EPA water end use estimates for hotels and motels. Table 8 shows how estimated non-potable demand was calculated based on the EPA water end use estimates, with toilet, cooling/heating, and outdoor/landscaping categories contributing to estimated total non-potable demand. (See Table 3 for more information on how toilet and sink estimates were calculated).

Table 7. Estimated non-potable demand based on EPA end use estimates: Hotel/Motel

End Use	% of total water demand
Kitchen/Dishwashing	14
Outdoor/Landscaping	17
Cooling/Heating	12
Toilets	11.4
Laundry	16
Other	11
Showers	9.6
Sinks	9
Total estimated non-potable demand	**40.4**

The Hotel/Motel land use category also required modifications. As with office parcels, non-potable water demand comprises a significant portion of total water demand for hotel and motel parcels, but the majority of this demand also consists of the water used by building cooling/heating processes and irrigation for landscaping. A similar visual scan and analysis process as the one described above was conducted for hotels and motels. Hotels and motels with landscaping and/or cooling towers were found to have more variability in terms of lot size, and thus, number of stories appeared to be a more accurate attribute to use in generating an assumption about the non-potable water demand of hotels/motels. It was determined that any given hotel or motel must be more than 3 stories high to be considered as having high non-potable potential.

Institutions (Hospitals only)

The estimated non-potable demand for the Institutions (Hospitals only) land use category was calculated based on the EPA water end use estimates for hospitals. Hospitals were the only type of parcel to which EPA water end use estimates were applied from the Institutions land use category because the remainder of parcels in this land use category are churches and clubs. A review of available literature and case studies on non-potable reuse systems found no reference to implementation of, or potential for, non-potable reuse

systems in churches or clubs. Table 9 shows how estimated non-potable demand was calculated based on the EPA water end use estimates, with toilets, cooling/heating, and outdoor/landscaping categories contributing to estimated total non-potable demand. (See Table 2 for more information on how toilet and sink estimates were calculated).

Table 8. Estimated non-potable demand based on EPA end use estimates: Institutions (Hospitals only)

End Use	% of total water demand
Kitchen/Dishwashing	7
Outdoor/Landscaping	7
Cooling/Heating	20
Toilets	19.6
Sinks	15.4
Other	7
Medical Equipment	15
Laundry	9
Total estimated non-potable demand	**46.6**

The resulting estimated non-potable demand for 7 of the 20 City of Seattle existing land use categories is shown in table 9.

Table 9. Estimated non-potable demand by land use category

Land Use (from Existing Land Use – 20 Categories)	Estimated Non-Potable Demand (% of total water demand)
Other Housing	62.1
Multi-Family	62.1
Mixed-Use	62.1
Hotel/Motel	40.4
Office	70.6
Institutions (Hospitals only)	46.6
Schools	64.2

2.2.2 Non-Potable Demand Based on Alternative Sources

US EPA land use categories were not a good fit for the other City of Seattle land use categories. In these cases, case study research into non-potable reuse applications was used to determine which additional land use types should be categorized as having high potential demand. This was done for the following land use categories:

- Single Family
- Duplex/Triplex
- Research Labs
- Retail/Service
- Public Facilities
- Open Space
- Entertainment
- Transportation/Utility/Communications
- Industrial
- Warehouse
- Parking
- Waterbody
- Easement
- Vacant
- Unknown

Single Family and Duplex/Triplex

A review of available literature and case studies on non-potable reuse systems found no reference to implementation of, or potential for district scale non-potable reuse systems in single-family or duplex/triplex residential blocks or neighborhoods (National Blue Ribbon Commission for Onsite Non-potable Water Systems, 2018), (Vandegrift, 2014). Therefore, this analysis assumed that non-potable reuse systems in areas zoned as single-family or duplex/triplex is non-feasible and those land use categories were designated as having low potential demand.

Research Labs

A review of available literature and case studies on non-potable reuse systems found reference to the potential for non-potable reuse systems in research labs due to the ratio of non-potable end uses to potable end uses (Vandegrift, 2014). Based on this, research labs were designated as high potential. Research labs are not one of the existing land use 20 categories, but rather are embedded within multiple of those 20 categories, including Public Facilities and Transportation/Utility/Communications. A manual search was done in GIS to find and extract all research labs within city limits in order to designate them as likely to have high non-potable water demand.

Retail/Service

The Retail/Service land use category includes the following "present use" types: auto showroom/lot, car wash, convenience stores, groceries, historic properties, mini lube, retail store, service building, service station, shopping center, veterinarian offices, restaurants, and breweries. A review of available literature and case studies on non-potable reuse systems found no reference to implementation of, or potential for, non-potable reuse systems in the business types listed above, apart from breweries. Several California breweries have implemented non-potable water reuse strategies to conserve water in the face of drought, for example (Glennon, 2018). Based on case studies such as this, breweries were designated as high potential. A search was done in GIS to find and extract all breweries from the Retail/Service land use category in order to designate them as likely to have high non-potable water demand. The remaining parcels in this category were deemed low potential.

Public Facilities

The Public Facilities land use category includes the following "present use" types: courthouses, libraries, fire stations, detention facilities, community centers, substations, police stations, post offices, garages, youth centers, and pump stations. A review of available literature and case studies on non-potable reuse systems did not find reference to implementation of, or potential for, non-potable reuse systems in the "present use" types listed above, apart from detention facilities and fire department training facilities (Vandegrift, 2014). Based on this, detention facilities and the Seattle Fire Joint Training Facility were designated as likely to have high potential non-potable water demand. A search was done in GIS to find and extract all detention facilities and the Seattle Joint Training Facility from the Public Facilities land use category. The remaining parcels in this category were deemed low potential.

Open Space

A review of available literature and case studies on non-potable reuse systems found reference to the potential for non-potable reuse systems in open spaces because much of the water demand for this land use category is for irrigation, and the water used to irrigate landscapes has the potential to be replaced with non-potable water (Tully & Young Comprehensive Water Planning, 2007). Based on this, all parcels in the Open Space land use category were designated as likely to have high potential non-potable water demand.

Entertainment

The Entertainment land use category includes the following "present use" types: art gallery, museum, social service, auditorium, bowling alley, driving range, health club, historic property, marina, movie theater, skating rink, and sport facility. A review of available literature and case studies on non-potable reuse systems found no reference to implementation of, or potential for, non-potable reuse systems in the "present use" types listed above, except for parcels with a significant amount of irrigated land area, such as driving ranges, for example.

In order to ensure that the potential for landscaped areas to be irrigated with non-potable water was captured for the Entertainment land use category, a manual scan for parcels with at least 50% landscaped

area was done using satellite imagery in GIS to find and extract all such parcels in order to designate them as likely to have high non-potable water demand. Fifty percent or greater of landscaped area was chosen as the threshold for whether a given parcel should be considered as having high non-potable potential due to the significant proportion of total water use that is used to irrigate large landscaped areas, and the potential for water used to irrigate landscapes to be replaced with non-potable water. Examples of parcels in the Entertainment land use category that were designated as likely to have high potential non-potable water demand include the Puetz Golf Course and several of the parcels that comprise Seattle Center. The remaining parcels in this category were deemed low potential.

Transportation/Utility/Communications

The Transportation/Utility/Communications land use category includes the following "present use" types: rail terminals, marine terminals, commercial fishing terminals, air terminals and hangers, bus terminals, substations, pump stations, reservoirs, utility control centers, and private utilities such as radio and television. A review of available literature and case studies on non-potable reuse systems did not find reference to implementation of, or potential for, non-potable reuse systems in the parcel types listed above, except for parcels with a significant amount of irrigated land area. In order to ensure that the potential for landscaped areas to be irrigated with non-potable water was captured for the Transportation/Utility/Communications land use category, a manual scan for parcels with at least 50% landscaped area was done using satellite imagery in GIS to find and extract all such parcels in order to designate them as likely to have high non-potable water demand. Because only one such parcel was found, the West Seattle Reservoir, that parcel was added to the Open Space land use category in this analysis. The remaining parcels in this category were deemed low potential.

Industrial

The Industrial land use category was treated differently than the other existing land use categories in this analysis. For other land use categories, "present use" types in the dataset provide a description that is specific enough to make a determination about which parcels have potential to utilize non-potable reuse systems. However, the Industrial land use category includes "present use" types such as warehouse, office and warehouse, loft, factory, shop, machine shop, processing plant, industrial building, artist studio, light industrial, indoor sports building, cleaners, metal prefab industrial building, paint shop, etc. While a few of these "present use" types are specific, most are not specific enough to make a determination about their potential to utilize non-potable reuse systems. While other fields in the dataset, such as property name, are helpful for some parcels, the property names for the majority of the 837 parcels in the Industrial land use category are also not specific enough to determine what business activities are occurring there, and therefore what potential exists for those parcels to utilize non-potable reuse systems.

However, a review of available literature and case studies on non-potable reuse systems found reference to implementation of, or potential for, non-potable reuse systems in certain industrial end uses of water, such as dust control, power washing, and manufacturing processes, in addition to toilet flushing, heating/cooling, and irrigation (Wells, 2019). In order to ensure that the potential for industrial land uses to utilize non-potable water was captured, all parcels in the category were designated as likely to have high potential non-

potable water demand. Therefore, a more refined analysis of a given high potential cluster that includes parcels in the industrial land use category may find that certain industrial parcels do not have as much potential as this analysis suggests.

Warehouse

The Warehouse land use category includes the following "present use" types: warehouse, mini-warehouse, historic property, office and storage, restaurant, shop/office, thrift store, service garage, apartment, wholesale grocery, and public storage. Like the Industrial land use category, these "present use" types are not explicit enough to make a determination about their potential to utilize non-potable reuse systems. Other fields in the dataset, such as property name, are helpful in determining what business activities might occur on many of the parcels in the Warehouse land use category. (Examples of property names in the Warehouse land use category include "Vaupell Industrial Plastics", "Light Manufacturing Warehouse", "Floral Supply Syndicate", "Ecolights", etc.) However, a review of available literature and case studies on non-potable reuse systems did not find reference to implementation of, or potential for, non-potable reuse systems in those types of business activities. Therefore, the warehouse land use category was designated as low potential.

Parking

A review of available literature and case studies on non-potable reuse systems found no reference to implementation of, or potential for, non-potable reuse systems in parking areas. Therefore, the Parking land use category was designated as low potential.

Water Body, Easement, Vacant, Unknown

Waterbodies and Easements are not land use categories that utilize water, and there is not enough information about parcels in the Vacant and Unknown land use categories to make a determination about how they utilize water or will use water in the future. Therefore, all 4 remaining land use categories were determined to be inapplicable to this analysis and were designated as low potential.

Table 10 provides a complete list of "Existing Land Use - 20" categories and summarizes how each category was treated in this analysis, its designation of potential, and the basis for that designation.

Table 10. "Existing Land Use - 20 Categories" designations of potential demand.			
Existing Land Use – 20 Categories	**Potential Demand**	**Uses within 20 categories**	**Basis for Designation**
Single-Family	Low	All	Water reuse case studies, other research
Duplex/Triplex	Low	All	Water reuse case studies, other research
Other Housing	High	Parcels with 50 or more units only	US EPA estimates of typical water end uses: favorable non-potable: potable ratio
Multi-Family	High	Parcels with 50 or more units only	US EPA estimates of typical water end uses: favorable non-potable: potable ratio
Office	High	Either lot size over 10,000 sq. ft. or over 4 stories high only	US EPA estimates of typical water end uses: favorable non-potable: potable ratio
Retail/Service	High	Breweries only	Selection based upon water reuse case studies, other research
Hotel/Motel	High	Parcels over 3 stories high only	US EPA estimates of typical water end uses: favorable non-potable: potable ratio
Entertainment	High	Parcels with over 50% irrigable land only.	US EPA estimates of typical water end uses: favorable non-potable: potable ratio
Mixed-Use	High	Parcels with 50 or more units only	US EPA estimates of typical water end uses: favorable non-potable: potable ratio
Parking	Low	All	Water reuse case studies, other research
Industrial	High	All	Water reuse case studies, other research
Warehouse	Low	All	Water reuse case studies, other research
Transportation/Utility/Communications	High	Select parcels only – added to open space category, research labs category	Specific building use, water reuse case studies
Institutions	High	Hospitals only	US EPA estimates of typical water end uses: favorable non-potable: potable ratio
Public Facilities	High	Detention facilities and fire department training facilities only	Specific building use, water reuse case studies
Schools	High	All	US EPA estimates of typical water end uses: favorable non-potable: potable ratio
Open Space	High	All	Water reuse case studies, other research
Waterbody	Low	All	Land use not applicable to analysis
Easement	Low	All	Land use not applicable to analysis
Vacant	Low	All	Land use not applicable to analysis
Unknown	Low	All	Land use not applicable to analysis

(appears in various land use categories)	High	Research labs	US EPA estimates of typical water end uses: favorable non-potable: potable ratio

To create the high potential by land use dataset, each of the categories that were designated as high potential in Table 2 were individually extracted from the from the "Existing Land Use – 20 Categories" dataset using the "Select by Attribute" tool in GIS. This process created 14 separate datasets, one for each of the categories designated as high potential in Table 2. Then, the 14 datasets were combined into a single new dataset, "High Potential by Land Use", using the "Merge" tool in GIS.

3. Results

Figure 3 shows the Intensive Water Consumer dataset created for this analysis by annual volume used. According to this analysis, approximately 2,440 parcels, or 1% of all parcels within the City of Seattle, were found to be intensive potable water consumers. These parcels account for 8% of the City's total land area.

Figure 4 shows the same Intensive Water Consumer dataset but displayed by annual volume used per acre.

Figure 5 shows the High Potential by Land Use dataset. Approximately 3,751 parcels, or 1.6% of all parcels within the City, were found to have high potential demand based upon their land use designation. These parcels account for 9.5% of the City's total land area.

Figure 6 shows the High Potential by Land Use dataset together with the Intensive Water Consumer dataset by annual volume used per acre to display which parcels are both intensive potable water consumers and have high potential non-potable demand. The Intensive Water Consumers by annual volume used per acre was used rather than the Intensive Water Consumers by annual volume because the goal of this analysis was to find clusters of parcels that could represent demand for a district-scale system (not a reuse system for single parcels). Approximately 1,325 parcels, or 0.05% of all parcels within the City, are both intensive water consumers and have high potential non-potable demand based upon their land use designation. These parcels account for 3% of the City's total land area. Figure 7 also shows the High Potential by Land Use dataset together with the Intensive Water Consumer dataset by annual volume used per acre, but is zoomed in to show the downtown vicinity, as this area has a large concentration of parcels that are both intensive water consumers and have high potential non-potable demand, and this area is obscured on the citywide map.

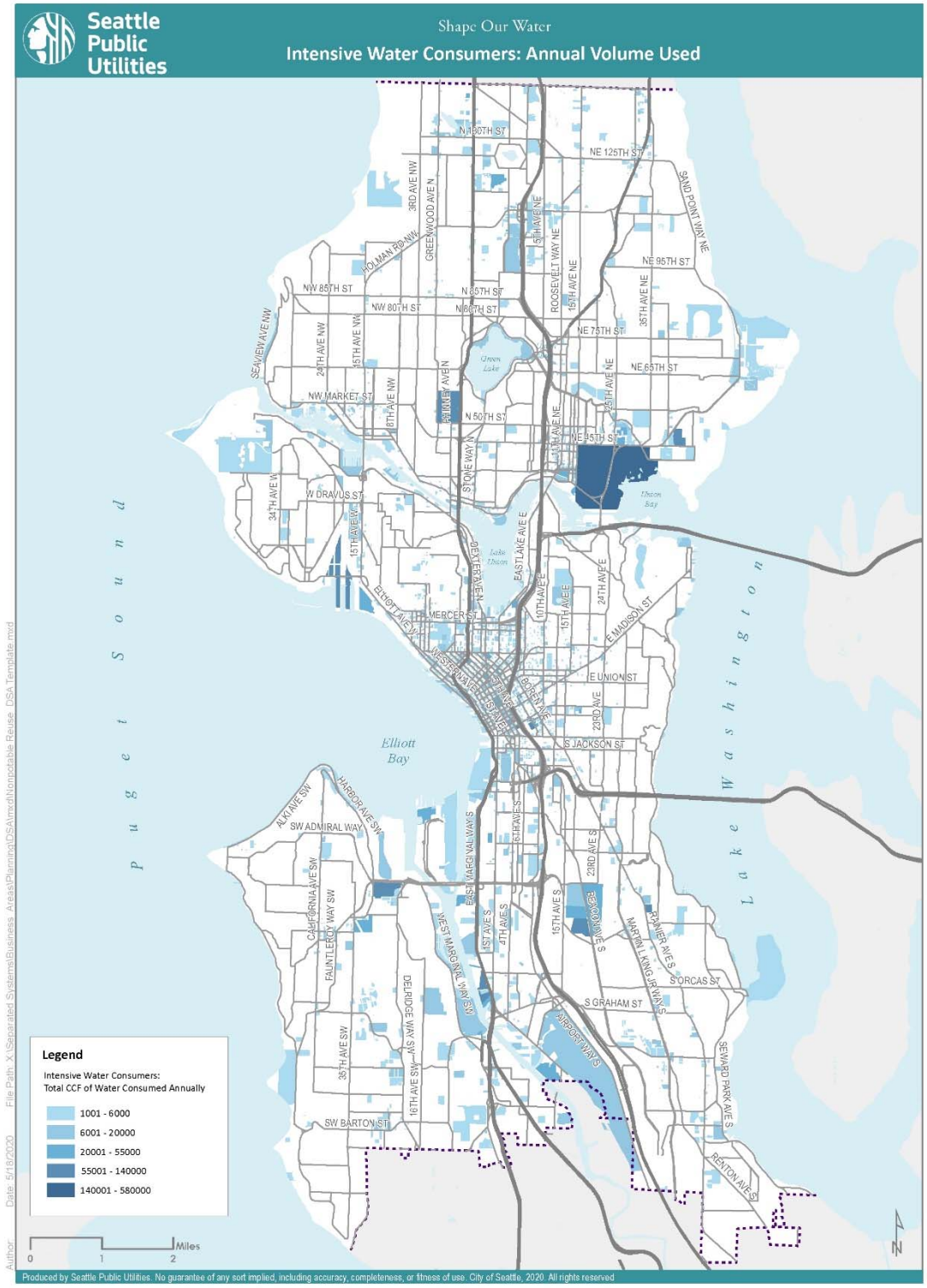

Figure 3. Intensive Water Consumers" Annual Volume Used map.

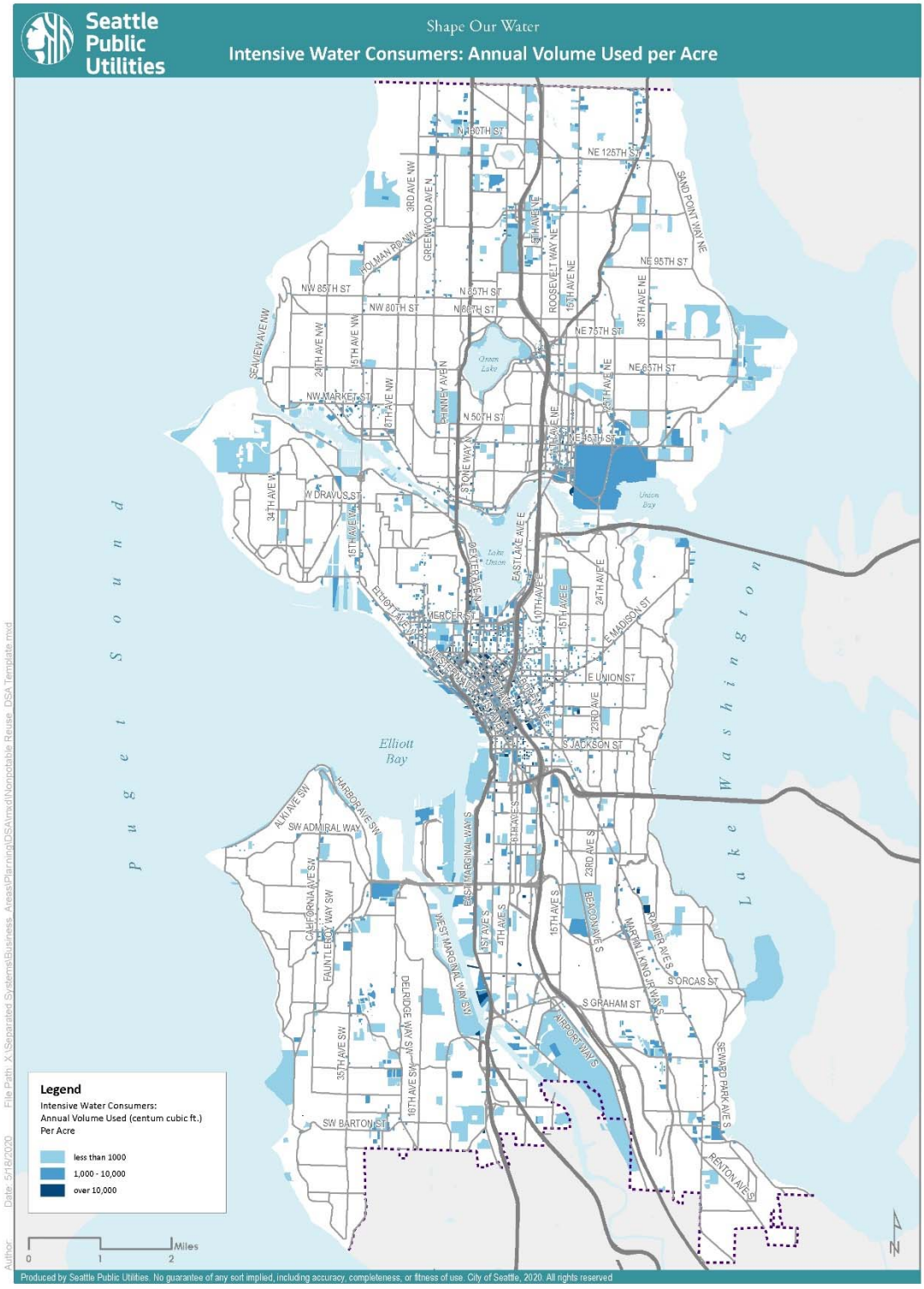

Figure 4. Intensive Water Consumers: Annual Volume Used per Acre map.

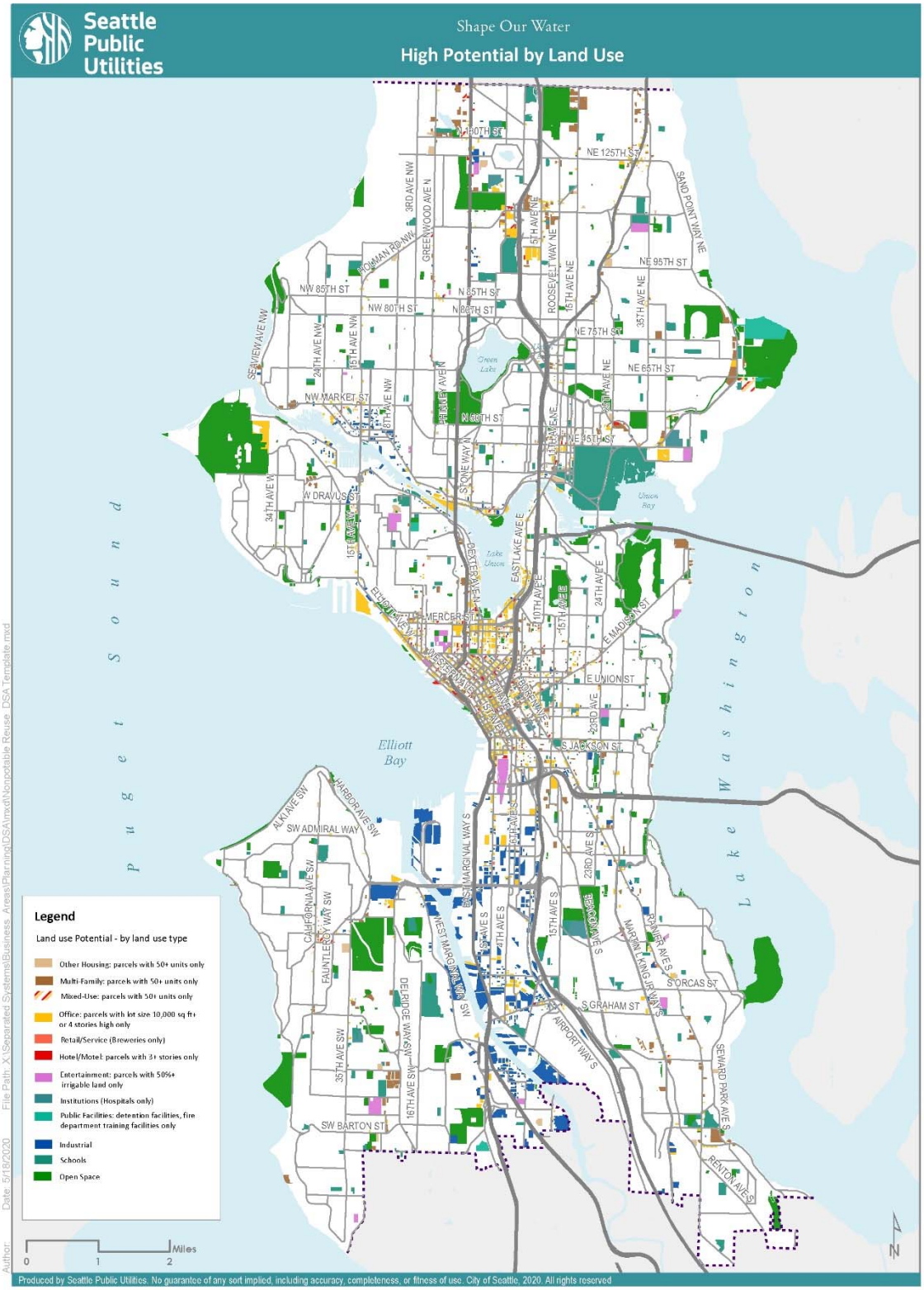

Figure 5. High Potential by Land Use map.

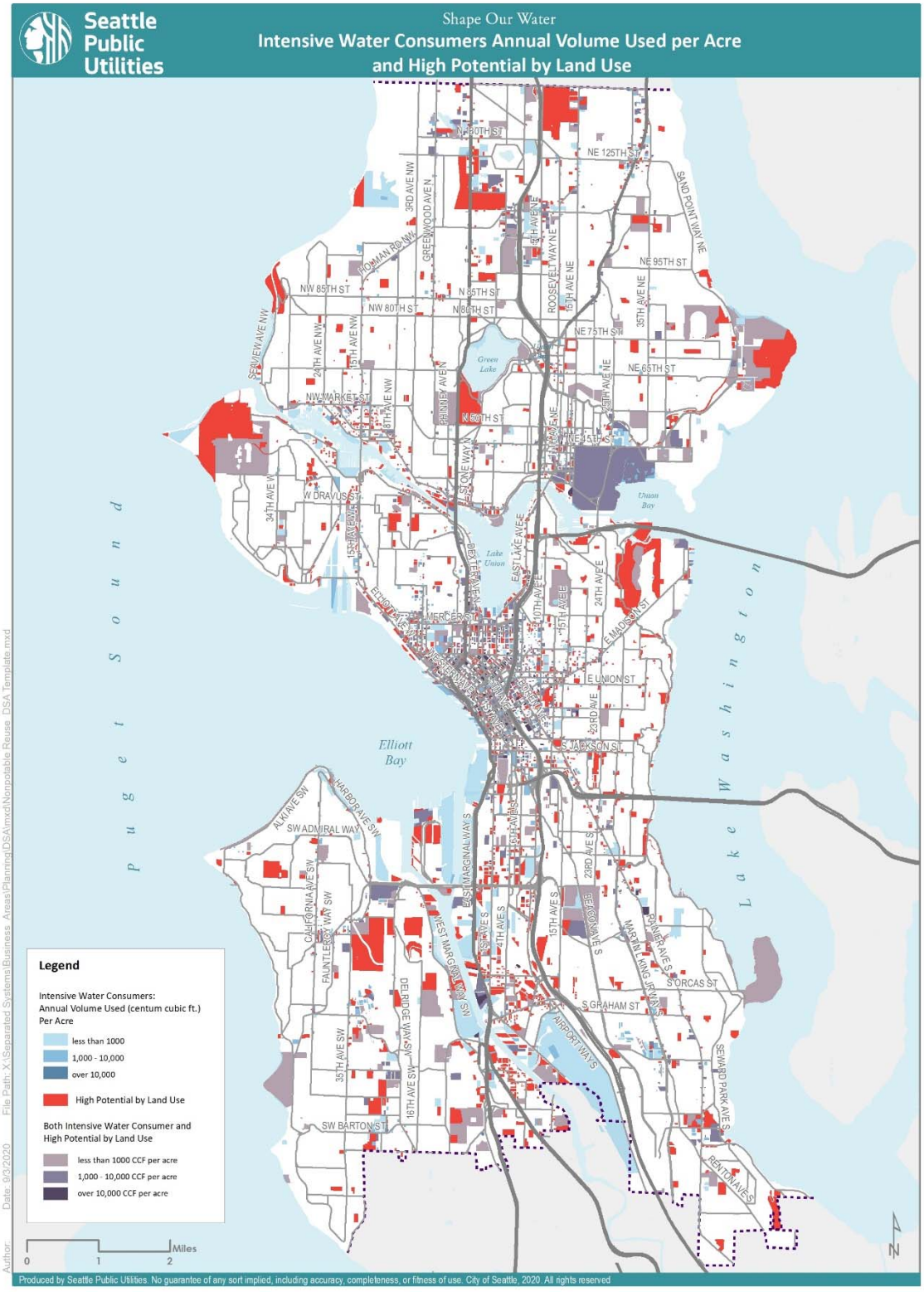

Figure 6. Intensive Water Consumers and High Potential by Land Use map.

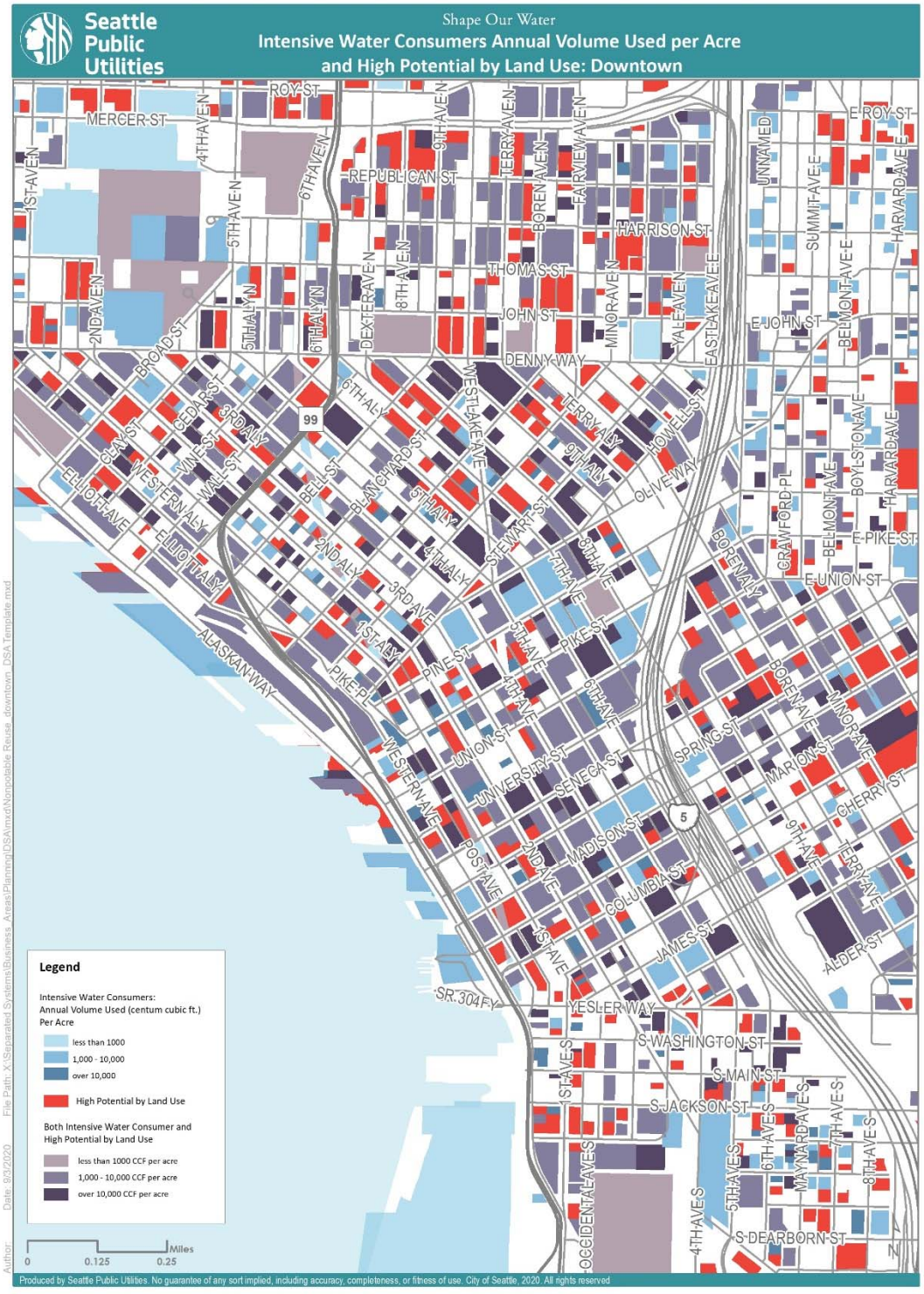

Figure 7. Intensive Water Consumers and High Potential by Land Use: Downtown map.

Clusters of parcels that are both intensive water consumers and have high potential non-potable demand represent the greatest overall opportunity to utilize district scale non-potable reuse systems. Figure 8 shows the two datasets together to display which parcels are both intensive potable water consumers and have high potential non-potable demand, with clusters of potential circled in black. While this analysis does not assess feasibility at the parcel or district scale, a scan of the datasets reveals potential clusters of interest in the following areas:

- Downtown

The Downtown Urban Center is the densest area of the city and therefore is likely also the cluster with the great density of demand. It is also the largest cluster in terms of overall land area. The vast majority of parcels within the high potential cluster of downtown are in the Office land use category, with Hotel/Motel, Multi-Family, Mixed-Use, Public Facilities and Entertainment parcels mixed in. Nearly every block in the downtown area features a parcel that is either an intensive water consumer, is high potential by land use, or both. The majority of high potential parcels are both high potential by land use and intensive water consumers. The downtown area appears to have the greatest overall demand density/highest density of demand.

- Uptown

Immediately adjacent to the downtown area, the Uptown Urban Center is similar to Downtown in that it is one of the largest clusters in terms of overall land area and density of demand within it, but demand is slightly less densely concentrated in this area, with high potential parcels occurring approximately every other block. Parcels in this cluster are approximately evenly split between intensive water consumer parcels, parcels that are high potential by land use, and parcels that are both. Most parcels are the size of one city block. Like downtown, the majority of parcels are in the Office land use category, but the Uptown high potential cluster has a greater number of parcels in the Mixed-Use and Multi-Family land use category than the Downtown Urban Center. This cluster also includes Seattle Center, which is comprised of several large parcels.

- South Lake Union

Adjacent to both the Downtown and Uptown Urban Centers, the South Lake Union Urban Center appears to have a demand density that is comparable to Downtown, with parcels that are both intensive water consumers and high potential by land use on nearly every block. The majority of high potential parcels in the South Lake Union cluster are both high potential by land use and intensive water consumers. The land use composition of this cluster is similar to that of the Downtown and Uptown clusters, predominantly featuring parcels in the Office land use category interspersed with Mixed-Use, Other Housing, Multi-Family, Hotel/Motel, and Open Space parcels interspersed. Most parcels are the size of one city block.

- First Hill/Capitol Hill

The First Hill/Capitol Hill cluster overlaps entirely with the First Hill/Capitol Hill Urban Center and features a wider variety of land use categories than the adjacent Downtown and South Lake Union Urban Centers.

Parcels in this cluster are approximately evenly split between intensive water consumer parcels, parcels that are high potential by land use, and parcels that are both. The First Hill area of this cluster appears to have a higher density of demand than the Capitol Hill area, with high potential parcels located on nearly every block. The majority of the city's hospitals are located in First Hill, most of which are both intensive water consumers and high potential by land use. Other dominant land use types in this cluster include Multi-Family, Office, and Mixed-Use parcels. First Hill/Capitol Hill is also home to Seattle University, comprised of several large parcels, all of which appear either in the high potential by land use dataset or in both datasets.

- Duwamish River Valley

The high potential clusters in the Duwamish River Valley are made up almost entirely of parcels in the Industrial land use category, with Open Space and School parcels interspersed. Contained completely within the Greater Duwamish Manufacturing Industrial Center, average high potential parcel sizes in this area are much larger than within other high potential clusters in the city, and thus, density of demand is almost certainly lower than Downtown, for example. High potential parcels are approximately evenly split between intensive water consumer parcels, parcels that are high potential by land use, and parcels that are both. As discussed in section 2.2.2, the Industrial land use category was treated differently than other land use categories in the analysis due to the lack of specificity that the Existing Land Use – 20 Categories dataset provides on Industrial parcels compared to other land uses. Because most high potential parcels in this cluster are in the Industrial land use category, a more refined analysis of this area may find that the Duwamish River Valley clusters do not have as much potential as this analysis suggests.

- South Delridge/Roxhill

The high potential cluster in the South Delridge/Roxhill neighborhood is much smaller in land area than those of Downtown, Uptown, South Lake Union, First Hill/Capitol Hill, and the Duwamish River Valley, but among the denser of high potential clusters, with high potential parcels adjacent to each other. Consisting of parcels in the Entertainment, School, Multi-Family, Other Housing, Office, Open Space, and Retail/Service land use categories, the cluster partially overlaps with the Westwood-Highland Park Residential Urban Village. Parcels in this cluster are approximately evenly split between intensive water consumer parcels, parcels that are high potential by land use, and parcels that are both Large parcels that are part of one or both datasets include a Seattle Public School stadium and sports field, the Westwood Village shopping center, and Roxhill Park.

- Beacon Hill

The high-potential cluster in the Beacon Hill neighborhood is larger in land area than other clusters in South Seattle, but has a lesser density of demand, as most of the area is made up of a few large parcels. Most high-potential parcels in the cluster are both intensive water consumers and high potential by land use, and includes parcels in the Open Space, Institutions, Schools, and Transportation/Utility/Communications categories. Clustered around the arterial Beacon Ave S, the largest parcels that make up the cluster are Jefferson Park, the Jefferson Park golf course, the Puget Sound Health Care System VA Hospital, and Asa Mercer Junior High School.

- Columbia City

The high potential cluster in the Columbia City neighborhood is one of the smallest in land area and appears to have a lesser density of demand than most, with high potential parcels generally separated from each other by one block. Parcels in this cluster are approximately evenly split between intensive water consumer parcels, parcels that are high potential by land use, and parcels that are both. Contained almost completely within the Columbia City Residential Urban Village, a greater variety of land use categories are represented in this cluster than others, including parcels in the Entertainment, School, Multi-Family, Office, Industrial, and Other Housing land use categories. Most high potential parcels are concentrated along the arterial street Rainier Ave S.

- Othello

The high potential cluster in the Othello neighborhood is slightly larger in land area and appears to have a higher density of demand than the nearby Columbia City cluster. The majority of parcels in this cluster are intensive water consumers or are both high potential by land use and intensive water consumers. Entirely contained within the Othello Residential Urban Village, this cluster includes parcels in the Multi-Family, Open Space, Office, School, and Retail/Service land use categories. The majority of high potential parcels in this cluster are concentrated along, or are one or two blocks from, the arterial street Martin Luther King Jr. Way. The New Holly public housing subdivision also makes up a significant portion of the cluster.

- Rainier Beach

The high potential cluster in the Rainier Beach neighborhood is slightly larger than the Othello cluster in area and appears to have a slightly greater density of demand than the Othello cluster with most high potential parcels adjacent to each other. The majority of parcels in this cluster are high potential by land use or are both high potential by land use and intensive water consumers. It is mostly contained with the Rainier Beach Residential Urban Village, with a few high potential parcels lying just outside the Residential Urban Village boundary. Consisting of parcels in the Multi-Family, Other Housing, Industrial, Open Space, Office, School, and Retail/Service land use categories, most are concentrated along the arterial street Rainier Ave S. The large parcels of Rainier Beach High School, Rainier Beach High School sports complex, and South Shore Middle School and Lake Washington Apartments comprise the majority of the area within this cluster.

- Ballard

The high potential cluster in the Ballard neighborhood is the least dense of the 14 high potential clusters, with high potential parcels up to one block apart in some areas. The majority of parcels in this cluster are high potential by land use. Consisting mostly of parcels in the Industrial land use category, the cluster overlaps with the Ballard-Interbay-Northend Manufacturing Industrial Center, as well as the southern portion of the Ballard Hub Urban Village. Other parcels are within the Office, Mixed-Use, Multi-Family, and Open Space, and Retail/Service land use categories, including 9 breweries. As discussed in section 2.2.2, the Industrial land use category was treated differently than other land use categories in the analysis due to the lack of specificity that the Existing Land Use – 20 Categories dataset provides on Industrial parcels compared to other land uses. Because most high potential parcels in this cluster are in the Industrial land

use category, a more refined analysis of this area may find that the Ballard high potential cluster does not have as much potential as this analysis suggests.

- Sand Point

The high potential cluster in the Sand Point neighborhood is one of the largest in terms of land area, but is comprised primarily of large parcels, and thus it is likely one of the lowest densities of demand, despite the close proximity of high potential parcels to each other. The majority of high potential parcels in the Sand Point cluster are both high potential by land use and intensive water consumers. This cluster includes parcels in the Open Space, Multi-Family, Public Facilities, School, Office, and Mixed-Use land use categories. The large parcels that comprise most of the cluster are Magnuson Park, the Sand Point Country Club, and the NOAA Western Regional Center facility.

- Lake City

The high potential cluster in the Lake City neighborhood is almost entirely contained within the Lake City Hub Urban Village and is among the smallest in terms of area of the high potential clusters, and also appears to have a lesser density of demand than most, with approximately half of all high potential parcels separated from each other by at least one block. Parcels in this cluster are approximately evenly split between intensive water consumer parcels, parcels that are high potential by land use, and parcels that are both. Consisting of parcels in the Mixed-Use, Office, Multi-Family, Open Space, and Retail/Service land use categories, most are concentrated along the arterial street Lake City Ave NE.

- Northgate

The high potential cluster in the Northgate neighborhood is among the largest in land area, and appears to be relatively dense, with most high potential parcels adjacent to each other. The cluster overlaps almost completely with the Northgate Urban Center, with a few large high potential parcels, such as North Seattle Community College, lying just beyond the Urban Center boundary. Parcels in this cluster are approximately evenly split between intensive water consumer parcels, parcels that are high potential by land use, and parcels that are both. This cluster consists mostly of parcels in the Multi-Family and Office land use categories, but the Other Housing, Schools, Hotel/Motel, and Mixed-Use land use categories are also represented. Interstate 5 bisects the Northgate Urban Center and the high potential cluster. The Northgate Urban Center and the Bitter Lake Hub Urban Village are separated by one block, but the two high potential clusters in these areas could alternatively be considered as a single mega-cluster, as there is no separation between their high potential parcels.

- Bitter Lake

The high potential cluster in the Bitter Lake neighborhood is among the largest in land area, and appears to be relatively dense, with most high potential parcels adjacent to each other. It overlaps significantly with the Bitter Lake Hub Urban Village with a wide variety of land use categories represented, including Industrial, Open Space, Entertainment, Other Housing, Hotel/Motel, Multi-Family, Office, School, Retail/Service, and

Public Facilities. Parcels in this cluster are approximately evenly split between intensive water consumer parcels, parcels that are high potential by land use, and parcels that are both. The majority of high potential parcels in this cluster are concentrated along or are one or two blocks from the arterial street Aurora Avenue N. As aforementioned, the Bitter Lake Hub Urban Village and the Northgate Urban Center are separated by one block, but the two high potential clusters in these areas could alternatively be considered as a single mega-cluster, as there is no separation between their high potential parcels.

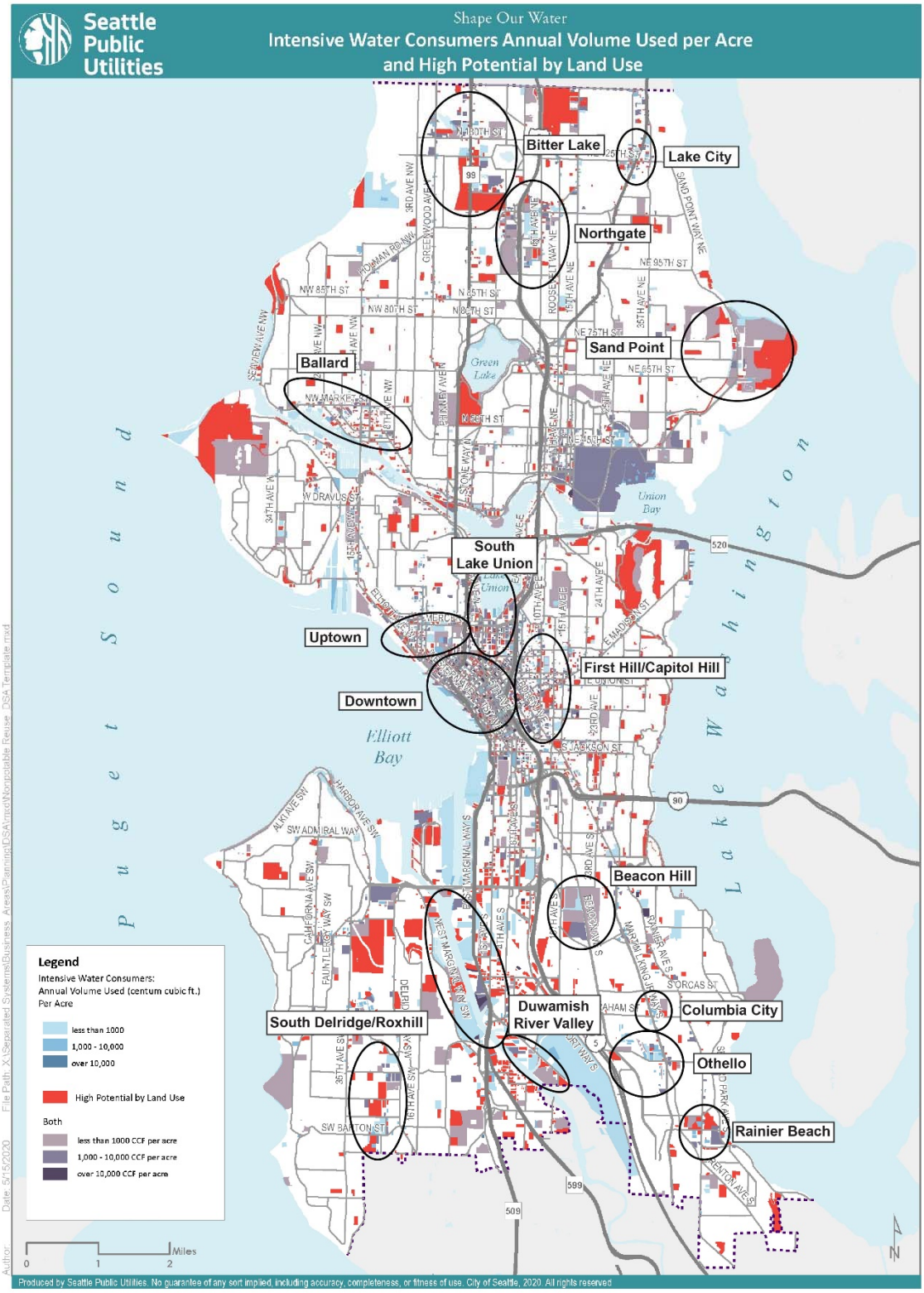

Figure 8. Intensive Water Consumers and High Potential by Land Use: Clusters of Potential map.

4. Recommendations for Future Use

This section presents recommendations for future use of the results from this analysis, including how information could be used both for the ISP and outside the ISP.

4.1 How information could be used for ISP

The GIS layers of High Potential by Land Use and Intensive Water Consumers can be analyzed with other identified challenges and opportunities in order to help develop potential solutions in the ISP. Areas identified as having high potential non-potable demand could be analyzed by the ISP team as possible opportunities to explore district scale non-potable reuse systems in areas where those systems could also relieve pressure on the drainage and wastewater system in capacity-constrained areas. Additionally, the ISP team could use this analysis to inform the development of policies or incentives for onsite non-potable water reuse systems at the parcel scale for new development.

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