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Non-residential Refill Rate Study

Economic & Land Use Forecasting
Measurement Program

October, 2011

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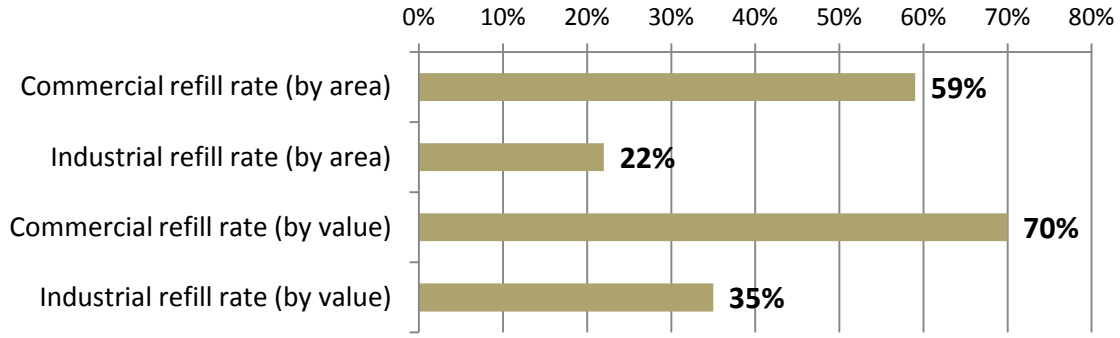
EXECUTIVE SUMMARY

This report presents the findings of the second non-residential refill study conducted by Metro's Economic and Land Use Forecasting unit. This study reviewed non-residential building permits issued in the Portland metropolitan region between 2001 and 2007 in order to determine the share of non-residential development occurring to redevelopment and infill development. Development is measured through new square footage and building permit value. Further, non-residential development is categorized as either "Industrial" or "Commercial" because these types of development have dramatically different profiles.

Of the 3,363 building permits reviewed, 1,742 were found to have added new capacity in the form of new building structures or additions. For these 1,742 permits, the non-residential refill rate was calculated to be 59% for commercial development and 22% for industrial development when measured by square feet of added capacity. In contrast, the refill rate measured through permit value was somewhat higher at 70% for commercial development and 35% for industrial development.

The data collected for this study may be used to evaluate how new square footage and building investments relate to employment growth, however that analysis is beyond the scope of this study directly.

Figure 1. 2001- 2007 Non-residential Refill Rates



INTRODUCTION

This report presents the second non-residential refill study conducted by Metro for the Portland metropolitan area. The goals of this study are to determine the non-residential refill rate for the period 2001 – 2007, with a particular focus upon the following:

- The amount and percentage of non-residential building permit value placed on land that Metro considered developed in 2000;
- The amount and percentage of non-residential square footage placed on land Metro considered developed in 2000; and

What is Refill?

Non-residential refill is a term that captures two types of activity: redevelopment and infill. Infill construction (Figure 1) is on land previously classified as developed, but which does not require demolition of an existing structure. Infill may result from dividing developed parcels or from building on land which is used for parking. Redevelopment (Figure 2) is construction that occurs after demolition of an existing structure on land also previously classified as developed. These categories are contrasted with development on land previously classified as vacant (Figure 3).

The **non-residential refill rate** is the percentage of new construction for commercial and industrial purposes that occurs on land already classified as developed with respect to the total new construction for commercial and industrial purposes in the same time period.
The refill rate can be measured in number of buildings, total square feet of construction, or in permit value. The refill rate does **not** refer to a proportion of the land base subject to infill or redevelopment.

Why is the Refill Rate Important?

The refill rate is directly connected to Metro's ability to determine how much non-residential land needs to be included within the Urban Growth Boundary. When estimating the land supply available, Metro takes into account the refill rate (per the requirements of O.R.S. 197.296 and 197.301).

The non-residential refill rate is also important in examining the relationship between new physical capacity and employment. Further, the impact on employment capacity due to non-residential refill can vary widely. Some types of building alterations may yield substantial increases in employment capacity (for example, new buildings or additions), whereas other alterations (i.e. external remodels, parking lot construction) may add no capacity at all.

Figure 2. Infill Development Example

2004 2010

Figure 3. Redevelopment Example

2006 2008 2010

Figure 4. Vacant Land Development Example

2004 2008

METHODOLOGY

The basic methodology for determining the refill rate is through reviewing building permits and determining how much, if any, new building square footage resulted from each building permit. These permit records are then consolidated to show the total amount of new square footage on vacant versus developed lands and for industrial versus commercial uses.

Source Data

Building permit data acquired through commercial sources is the base unit of analysis and is the source of the term "Permit Audit" coined to describe the non-residential refill research process. Metro has a master tabular database of building permits for the metro region of 275,000 records. This master set contains residential and non-residential records for the years 1998 to 2008. This file includes both "pending" and "approved" permits as well as records outside of the Metro region (e.g. Salem, Oregon, Yamhill County, etc.). The permit records were geocoded at the Data Research Center; Appendix A provides an analysis of the geocoding quality.

The permit records are consistently attributed with permit date and value. Other data, such as owner information, square footage, development units, and development description are provided but are inconsistently populated. Further, the development descriptions fluctuate from being highly specific (such as providing establishment names) to generic (such as providing an establishment type) to being non-descriptive entirely. These attributes were used to help determine location and type of development where available, but are not reliable as a basis of analysis. Permits were selected for audit based on the likelihood that they would add physical capacity and not simply signal a change in use. Permits were selected for evaluation if they met all of the following criteria:

- Permits with a class of "Commercial"
- Permit with a status of "Approved"
- Permits with a square foot value of greater than 1,000
- Permit with a value of greater than $1,000,000 if the description indicates a tenant improvement or remodel
- Permit with a value of greater than $50,000 if the description indicates an addition
- Permit with a value of greater than $100,000 when tenant improvement, remodel, or addition is not indicated

- Permit with a date of between January 2001 and December 2007

The resulting set included 3,624 building permits for evaluation. During the audit process, development was detected that was attributed to 53 permits not included in the selected set. During the analysis, 314 records were removed because they were outside the area of available data (243 records), determined to be duplicate permits (37 records), or the permit location could not be determined (34 records), thus the net number of reviewed permits was 3,363.

Of the 3,363 original permit records, only records meeting the following criteria were used to calculate refill rates:

- Those records inside the UGB boundary, AND
- Those records with new capacity (having new buildings and/or additions) AND
- Those records that have commercial or Industrial activity.

Based on these criteria, a subset of 1,740 records was used for the refill rate analysis.

Supporting GIS data for the permit audit included:

- In-house aerial imagery for the years 1994, 1996, and 2000 through 2010.
- RLIS layers including Tax lots, Streets, Vacant, Buildings, and Multi-Family Housing.

Other sources consulted for this project included:

- Internet mapping sources including, Google Maps, Google Streetview, and Bing Maps
- News outlets including OregonLive, *The Oregon Daily Journal of Commerce*, and *The Portland Business Journal*
- Developer and project websites

Workflow

The permit audit process followed the following workflow for each permit:

- **Determine actual location of the permit record**. Many of the permits did not geocode to the location of the building being constructed or altered. Permit information such as site address, owner, and description were used to determine the true location.
- **Determine "pre-permit" conditions.** The year 2000 tax lots and aerial imagery are for the year before the permit is used as the primary go-to source for determining pre-permit conditions.

- **Determine "post-permit conditions**. The year 2010 tax lots and aerial imagery for the year after the permit year are used to determine the conditions resulting from the permit.

The final permit audit data provided is listed in Table 1.Detailed descriptions and data capturing rules are provided in Appendix A. In the case of multiple permits issued for the same site, all new capacity will be assigned to a primary permit, usually the one with the largest payment value. Related permits for site development or tenant finish are related to the primary permit, but not included in the refill rate analysis.

Table 1. Primary Permit Audit Data Collected

Data Collected	Description
Pre-development Vacant/Developed Status	Two types of pre-development status are collected: **GIS Vacant** and **Economic Vacant**
Type of new capacity	This flag indicates the presence of a new building, and addition, or no new capacity.
New Square Footage	The total gross square footage is captured. For mixed-use developments, the net commercial square footage is also estimated.
Tear-down flag	This flag indicate whether there was a structure on site prior to development. This was not used in final refill rate calculation.
Type of activity on site	Flags for the type of development (e.g. industrial, commercial, or residential) are recorded for each permit.
Location Status	This flag shows whether the permit record is in the UGB, outside the UGB, or location is undetermined. Only records in the UGB were used in refill rate calculation.
Adjusted Permit Value	The value of the permit adjusted by the portion of the total square footage dedicated to commercial or industrial use.

FINDINGS

The 2001 – 2007 non-residential refill rate is calculated as the percentage of development that occurs on land that is classified as "Developed." Development is measured in two ways: based on total square footage and adjusted permit value.

2001 – 2007 Non-Res Refill Rate, measured by square footage

Using square footage as the measurement of development, the overall commercial refill rate is 59% while the overall industrial refill rate is 22%. Table 2 and Table 3 present these rates for the region and by county. These differences are explained by two factors: number of permits issued and the relative size of developments.

There were more than twice as many commercial refill developments as commercial developments on vacant lands. This much larger number of permits offset the fact that the median new square footage for commercial development on vacant lands (13,246 sq ft) was somewhat larger than the median square footage for similar refill development (8,419 sq ft).

In contrast, the much lower refill rate for industrial development reflects the fact that while the industrial permits were equally distributed between vacant and developed lands, the median new square footage size for vacant industrial development (36,160 sq ft) was much larger than the median square footage for vacant refill development (9,801 sq ft). Figure 4 provides an example of the very large industrial structures on vacant lands seen in this time period.

Table 2. 2001 – 2007 Commercial Refill rate, measured by square footage

County	Economic Vacant Status	Total Square Feet	Percentage	Number of Records
Clackamas	Developed	3,958,608	65%	189
	Vacant	2,164,073	35%	63
Multnomah	Developed	8,933,769	73%	436
	Vacant	3,349,401	27%	110
Washington	Developed	5,848,183	43%	310
	Vacant	7,665,478	57%	221
All counties combined	*Developed*	*18,720,560*	*59%*	*935*
	Vacant	*13,179,252*	*41%*	*394*

Table 3. Industrial Refill rate, measured by square footage

County	Economic Vacant Status	Total Square Feet	Percentage	Number of Records
Clackamas	Developed	836,358	28%	39
	Vacant	2,127,917	72%	42
Multnomah	Developed	2,129,515	19%	121
	Vacant	9,050,783	81%	110
Washington	Developed	1,118,979	28%	49
	Vacant	2,948,733	72%	52
All counties combined	*Developed*	*4,084,852*	*22%*	*209*
	Vacant	*14,127,433*	*78%*	*204*

Figure 5. Industrial Development north of Portland's Rivergate area

2000 2010

Much industrial development occurred on large tracts of vacant land. The new structures in this image were among the largest recorded in the permit audit.

2001 – 2007 Non-Residential Refill Rates, by permit value

The 2001-2007 refill rate measured by permit value was 70% for commercial development and 35% for industrial development. These values are presented for the region and by county in Table 4 and Table 5. This value-based commercial rate 11 percentage points higher than the square footage based rate. Similarly, the value-based industrial rate is 13 percentage points higher than the square footage based rate. The higher refill rate for permit value may, in part, be explained by the types of developments seen during the study period.

Many of the highest-value refill commercial structures included large institutional refill developments at OHSU, the Oregon Convention Center, new hospital structures, and numerous additions to educational institutions from primary schools to universities.

In contrast, common examples of significant commercial vacant development during the study period included retail and office development at Cascade Station, Happy Valley Town Center, or the streets of Tanasbourne. There was a small number of institutional developments on vacant land, the most notable being the Coffee Creek and Wapato correctional facilities Assuming that the institutional developments have more specialized requirements, these developments may be by nature of higher value than standard retail or office development.

Table 4. 2001 – 2007 Commercial Refill rate, measured by permit value

County	Economic Vacant Status	Total Value*	Percentage	Number of Records
Clackamas	Developed	$410,875,415	78%	189
	Vacant	$119,280,743	22%	63
Multnomah	Developed	$811,365,130	77%	436
	Vacant	$237,783,926	23%	110
Washington	Developed	$389,705,619	53%	310
	Vacant	$347,936,374	47%	221
All counties combined	*Developed*	*$1,611,946,164*	*70%*	*935*
	Vacant	*$705,001,043*	*30%*	*394*

Table 5. 2001 – 2007 Industrial Refill rate, measured by permit value

County	Economic Vacant Status	Total Value*	Percentage	Number of Records
Clackamas	Developed	$27,588,858	29%	39
	Vacant	$67,209,097	71%	42
Multnomah	Developed	$129,515,465	36%	121
	Vacant	$230,128,843	64%	110
Washington	Developed	$35,234,559	39%	49
	Vacant	$56,106,913	61%	52
All counties combined	*Developed*	*$192,338,882*	*35%*	*209*
	Vacant	*$353,444,853*	*65%*	*204*

APPENDIX A: COLLECTED PERMIT AUDIT DATA

1. Vacant/Developed Status

There are two Vacant/Developed statuses recorded for each permit. The **Economic Vacant** flag is the primary attribute collected to determine the refill rate**.** This flag counts as Developed land that has had any development, regardless of the status of the land in RLIS Vacant lands inventories. The data collection phase also distinguishes between two types of vacant lands (described in Table 6); however these variations are grouped together as "vacant" for purposes of calculating refill rate.

Table 6. Economic Vacant Flag Criteria

Economic Vacant Flag	Real-World Conditions
Vacant	No signs of previous development on property AND Parcel is not primarily in a built-up area
Vacant - Infill	Parcel is primarily in a built up area Parcel has no signs of previous development
Developed	Signs of previous development on site

A second status, **GIS Vacant,** is a flag that indicates whether the building of the development is on land coded as vacant in the 2000 Vacant lands layer. Values for this flag can be "Vacant," or "Developed." Figure 5 and Figure 6 show examples of both the **Economic Vacant** and **GIS Vacant** flags.

A small number of records are marked in opposite "Developed" or "Vacant" categories for the two vacant statuses because of the difference in definitions. Table 7 shows a cross tabulation of the **Economic Vacant** versus **GIS Vacant** for 1,742 permits with new capacity used to estimate refill rates. The majority of these differences are attributed to permits for locations that were classified as vacant in the 2000 inventory, but in which there was previous development (see Figure 7 and Figure 8 for examples.)

Figure 6. Development on Vacant-Infill land

2000

2010

The GIS Vacant status for this permit is "Vacant;" the Economic Vacant Flag for this development is "Vacant-Infill" because it is in a primarily built-up area.

Figure 7. Development Spanning Vacant and Developed Lands

2000

2010

The GIS Vacant status for this permit is "Developed;" the Economic Vacant Flag for this development is "Developed."

Table 7. GIS Vacant versus Economic Vacant Cross tabulation

		GIS Vacant		
		Developed	Vacant	*Total*
Economic Vacant	Developed	1,102	42	*1,144*
	Vacant – Greenfield	2	450	*452*
	Vacant – Infill	1	145	*146*
	Total	*1,105*	*637*	*1,742*

Figure 8. Redeveloped Land classified as GIS Vacant

1996 2000 2010

The GIS Vacant status for this permit is "Vacant;" the Economic Vacant Flag for this development is "Developed" because there is evidence of previous development.

Figure 9. Redeveloped Land classified as GIS Vacant in the Pearl District

1996 2000 2010

Much of the redevelopment of the Pearl district that occurred in the time-frame of this study occurred on land classified as Vacant in 2000, but which had previous industrial uses.

2. Type of New Capacity

The **New Capacity** field indicates whether the permit has resulted in a new structure, an addition to an existing structure, a non-building type structure, or no visible development. Table 8 provides a description of these flags and the number of occurrences of each in the total dataset. Figure 9 shows an example of new capacity through addition. For the refill rate calculation, only permits with "New building" or "Addition" are considered.

Table 8. New Capacity Flag Criteria

New Capacity Flag	Real-World Conditions	Number of Records
New Building	An observable, stand-alone new building is on the site. Note that the small number of records that result in new buildings and additions are coded as "New Building."	1,475
Addition	An addition is observed on a pre-existing building on the site.	400
Non-building structure	The permit refers to the following types of structures: - Pump houses - Mechanical coverings - Parking structures - Grading or site development - Electrical substations - Bus or MAX shelters These types are commonly identified in the permit description text itself.	421
No visible development	There is no observable new capacity on the site.	1,068
N/A	Records not evaluated (location unknown or outside UGB).	313

Figure 10. New Capacity Through Addition

2000 2010

The observed addition on the south side of this building yields to a New Capacity flag of "Addition."

3. New Square Footage

New square footage is estimated for each permit that has new capacity. The square footage is estimated as the area of the building footprint multiplied by the number of stories in the structure. Special cases in estimating square footage include:

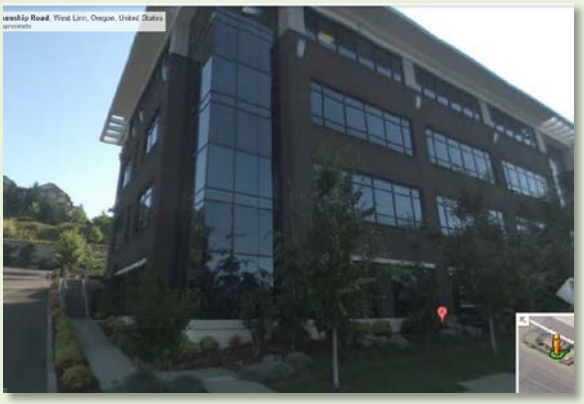
- For **mixed-use** residential & commercial development, only the commercial share of the square footage is captured. The commercial portion is presumed, in all cases, to be the building footprint itself and is not factored by additional stories.
- The square footage estimate is not decreased by any area of a whole or partial **tear down** on the site.
- For **additions**, only the new area is recorded.

The estimate for the building footprint may be derived from either the area of the RLIS Buildings layer or the area of a polygon drawn over the aerial imagery. The estimate for the number of stores in the structure drives from Google Streetview and Bing Bird's Eye View. Where possible, the height of the building in the RLIS Buildings layer is used to support the reasonableness of the number of stories estimate.

Note that the square footage estimated using this method will be much larger than what would be provided by an assessor's office or as a statement of net leasable area. Thus, the square footage resulting from the Permit Audit process cannot be used in conjunction with other estimates. Instead, it is a consistent method by which to compare only records within the audit process itself.

Figure 11. Estimation of permit square footage

2010 Aerial Imagery



2011 Google Streetview

The building footprint for this permit is 18,851 square feet and there are 4 stories in the building. Thus, square footage for this permit is recorded as 75,404.

4. Teardown Flag

The teardown flag is a binary flag indicating whether the site of development had a structure torn down prior to the development associated with the permit under review. This includes both entire structures and partial tear-downs. The teardown flag is not used in calculating the refill rate, but is captured as an auxiliary attribute for database checking.

Figure 12. Teardown prior to development

2000

2010

5. Activity Type

Activity type is captured for two reasons. First, refill rates are calculated separately for "commercial" versus "industrial" development. Additionally, a finer grain detail of activity type is captured to facilitate linking of permit records to employment databases in subsequent project steps. The detail and general activity types are described in Table 9.

Permits may be coded to multiple activity types. For example, mixed-use developments are coded as "commercial" and "residential." Activity types are researched through the permit description, tax lot information, and Google searches. Common special cases of categories that ARE included in the refill rate include:

- Mixed-use commercial/residential
- Care and custodial facilities such as assisted living, nursing homes, correctional institutions
- Home businesses, including care facilities

Common special cases that ARE NOT included in the refill rate include:

- College dormitories: These are coded as Institutional and Residential and are not considered in the refill rate analysis
- Pool houses or community buildings on residential developments
- Public housing (unless mixed-use with a retail establishment on-site)
- Park buildings

Table 9. Description of permit activity types

Detail Activity Type	General Activity Type	Examples
Commercial	Commercial	Development with a retail presence. Includes shops, banks, restaurants, car dealerships, churches, gas stations, day-care, auditoriums, etc.
Office	Commercial	Services or offices. Includes medical offices, hospitals, business services. Light industrial not coded as industrial falls in this category.
Institutional	Commercial	Schools, colleges, civic offices, correctional facilities
Care Facilities	Commercial	Nursing homes, assisted living, other types of group quarters.
Industrial	Industrial	Sites with 2010 Tax lot use classified as of Industrial
Residential	Not Considered	Residential housing that are not group quarters
Other	Not Considered	None of the above categories; most commonly parks and recreational spaces.

6. Location Status

The location status of permits indicates the location of the permit with respect to the Urban Growth Boundary. Table 10 describes the location status flags used and provides the number of occurrences of each flag in the database. For the refill rate calculation, only permits with the value "In UGB" were used.

Table 10. Location Status

Location Status Flag	Real-World Conditions	Number of Records
In UGB	The location for the permit is known and it is in the 2010 UGB boundary.	3,299
Out of UGB, but evaluated	The location for the permit is known and it is outside the 2010 UGB boundary. Source material was available for the permit and audit information was collected.	63
Out of UGB, not evaluated	The permit geocoded to a location outside of the 2010 UGB boundary. Source material was not available for the permit and audit information was not collected.	244
Location Unknown	The location of the permit could not be determined because of errors or ambiguities in the permit site address or description.	34
False Records	Permits deemed to be duplicates or for development that was never completed	37

7. Adjusted Permit Value

Permit value is an attribute of the permit records themselves. **Adjusted Permit Value** is a calculated field that pro-rates the total permit value by the percentage of the square footage that is for commercial development. Thus, the adjusted permit value is only different from the actual permit value for the records that have mixed residential/commercial uses.

8. Other Supporting Information

Where applicable, the **number of residential units** is collected for residential building permits with new capacity. This data is derived from the permit records

themselves (development units), from the RLIS Multi-Family Housing Inventory, or from web searches related to the development itself.

Long-string **comments** are collected for permits to track development type or unusual information that may be helpful in QA and review.

A **link to the Building layer** for each permit is used to capture the true location of the development.

APPENDIX B. PERMIT DATABASE GEOCODING ANALYSIS

Summary

Errors in the permit database geocodes include failure to determine the site location for a permit record or matching the permit record to an inaccurate location. Geocoding error rates in the permit database depend on how errors are defined, but generally an evaluation of the data reveals that:

- 3% - 7% of the permit records fail to geocode
- 4% - 14% of the permit records geocode to an inaccurate location

Reasons for geocoding errors of both types include:

- Errors in the permit address information including typos or standardization problems;
- errors or ambiguity in address locator data;
- changes in real-world address patterns between the time the permit was recorded and when the permit was geocoded.
- A small number of these errors have the potential to be corrected through changes in the geocoding process (for example, by using different locators or pre-processing the permit addresses). Most of the errors detected, however, cannot be resolved without intensive manual evaluation.

Geocoding Error evaluation

Geocoding Accuracy and the Permit Audit Process

A commercially available tabular database of building permits for the metro area was used as the basis for the non-residential refill rate analysis. The location for each permit was assigned through a systematic geocoding process at Metro's Data Resource Center. The geocoding process attempts to correctly assign a location to each permit using address information while limiting "false positive" address matches.

There is a risk that errors in the geocodes of the permit record database can introduce errors to the accuracy of the non-residential refill rate analysis: geocoding failures lead to permits that cannot be evaluated and a failure to detect development; assignment of inaccurate locations may lead to erroneous permit evaluations.

Additionally, because the audit process is essentially a manual verification of the geocoding accuracy of a 2% subset of the full permit database, an assessment of the database geocoding accuracy and error patterns can help inform what types of

projects would benefit from using the permit database and how the database could be improved.

Evaluation Method

Evaluation of the goodness of permit locations includes assessing the match rate and the accuracy rate. The match rate is gathered from the output results of the geocoded permit file itself; this is evaluated for all permit records.

In contrast, the accuracy rate is evaluated through a comparison of the geocoded location and the location of the development for each permit recoded as part of the manual permit audit process. This evaluation is only conducted on the subset of records selected for the non-residential refill rate audit and for which a development location was found.

Matching Rates

The overall geocoding match rate of the permit database is very high. Table 11 shows the geocoding match rate for the full permit database, including both residential and non-residential permit records. This full database also includes records for counties outside the Metro area.

Table 11. Geocoding Match Rate

Permit Database	Total Number of Records	Matched Records	Percent Matched
Full Permit Database			
• All records	278,258	258,280	93%
• 3-County region records	179,072	174,141	97%
Non-residential Refill Records			
• All records	3,677	3,565	97%
• 3-County region records	3,670	3,558	97%

While 7% of the full database records do not successfully geocode with the current process, many of these records are outside of the Metro area. For example, the full database includes 17,000 records for Salem, OR and 14,000 records for Vancouver, WA. When only records in Clackamas, Multnomah, and Washington counties are evaluated, the geocoding failure rate is only 3%.

Geocoding Error Patterns

Patterns of errors for permit database geocodes include the broad categories:

- Failure to match to a correct location because of errors in the permit site address information.
- Failure to match to a correct location because of changes in address information between the time the permit was recorded and when the permit was geocoded.
- Failure to match to a correct location because of errors or ambiguity in address locator data.

Examples of Geocoding Errors Due to Errors in the Permit Database

1. Permit Database Error: Typos in site address information

Many geocoding errors result from typos in the number or name portion of the address in the permit record itself. Errors in the number portion are likely not detectable or correctable without intensive manual review. Detection of errors in the name portion is possible by comparing the permit street names to a list of known street names in each jurisdiction.

Typos in the street type and directional quadrant are also observed. There are 50 unmatched occurrences of permits with the string " sst" and " ddr"; a selected sample of these geocoded successfully when the street type was corrected.

Table 12. Examples of permit record address errors

Permit Address	Real Address	Geocoding Result
8770 SW Scoffins St	**8700** SW Scoffins St	Segment level match w/ score of 88
2935 NE Halsey	**21935** NE Halsey	Address Unmatched
1422 N **Lomard** St	1422 N **Lombard** St	Address Unmatched
11883 SW **Hel** St	11883 SW **Itel** St	Address Unmatched
1624 NW Lovejoy **sst**	1624 NW Lovejoy **St**	Address Unmatched
10652 NE Holman **sst**	10652 NE Holman **St**	Address Unmatched

2. Permit Database Error: Extraneous information in site address

Many permit records contain building or suite information in the site address. This does not always lead to a geocoding failure, but it does appear to be the reason for a number of unmatched records. In the full permit file, there are 434 matched

occurrences with the string "Bldg" and 184 unmatched occurrences of the string "Bldg. "

Table 13. Examples of extra information in address field errors

Permit Address	Real Address	Geocoding Result
14500 N Lombard St **Bldg A**	14500 N Lombard St	Address Unmatched
239 N Sumner St **Bldg 12**	239 N Sumner St	Address Unmatched

3. Permit Database Error: Site address truncated

A small number of unmatched records were observed with truncated Site Address fields. The following two patterns account for about 25 missing records.

Table 14. Examples of truncated address information

Permit Address	Real Address	Geocoding Result
12931 Happy Valley Town **Ce**	12931 Happy Valley Town **Center Dr**	Address Unmatched
16037 SW Upper Boones Ferry **R**	16037 SW Upper Boones Ferry **Rd**	Address Unmatched

4. Permit Database Error: No address information

Over 4000 permit records have no site address information. This includes an address recorded with null or empty values and with ambiguous information ("Right of Way" or "Not Assigned Yet"). Some of these records include a tax lot identifier, however most are not geocodable.

5. Permit Database Error: Address standardization problems

Many common names are abbreviated in the permit records. There are dozens of unmatched variations of the Beaverton Hillsdale Highway, the Historic Columbia River Highway, Tualatin Valley Highway, Martin Luther King Boulevard, Happy Valley Town Center Drive, and Upper & Lower Boones Ferry Roads. Similarly, the interpretation of the street "Park Way" as "Parkway" (incorrect street name and type) resulted in 37 unmatched records alone.

Table 15. Examples of permit database standardization errors

Permit Address	Real Address	Geocoding Result
8205 SW **Bvtn Hillsdale** Hwy	8205 SW **Beaverton Hillsdale** Hwy	Address Unmatched
36023 **Historic Columbia R** Hwy	36023 E **Columbia River** Hwy	Address Unmatched
10164 SW **Parkway**	10164 SW **Park Way**	Address Unmatched

Examples of Geocoding Errors Due to Real-world Address changes

1. Real-world Address Changes: Systemic changes in addressing pattern

Changes in addressing scheme were detected in Sherwood (2005), Hillsboro (2003), and Tualatin (2002). Permits entered prior to the change-over year are unmatched when using the current locators. Sherwood has the most extensive changes; Hillsboro and Tualatin only had changes on larger arterials passing through several jurisdictions. There were 323 unmatched permits in these towns prior to each transition.

Table 16. Examples of system changes in addressing patterns

Permit Address	Real Address	Geocoding Result
380 Oregon St	15677 SW Oregon St	Address Unmatched
23105 SW Tualatin Valley Hwy	6577 SW Tualatin Valley Hwy	Address Unmatched
855 N Sherwood Blvd	21907 SW Sherwood Blvd	Address Unmatched

2. Real-World Address Changes: Development prior to address assignment

It was observed during the audit process that when lots were newly divided or developed, the development site often did not have a physical address at the time the permit was issued. In many of these cases, the address of the pre-divided lot or adjacent lot was with the same owner was entered as the permit site. The resulting permits are matched to an incorrect but nearby tax lot. Correcting the geocodes location of these permits through automated means is unlikely.

Table 17. Examples of development prior to address assignment

Permit Address	Real Address	Geocoding Result
37208 SW Florence Ln	7206 SW Florence Ln	Address matched with score of 100% to wrong parcel.
 2000 imagery & tax lots	 2010 imagery & tax lots	The cyan dot in each image shows geocoded permit location of for development on the subdivided parcel.

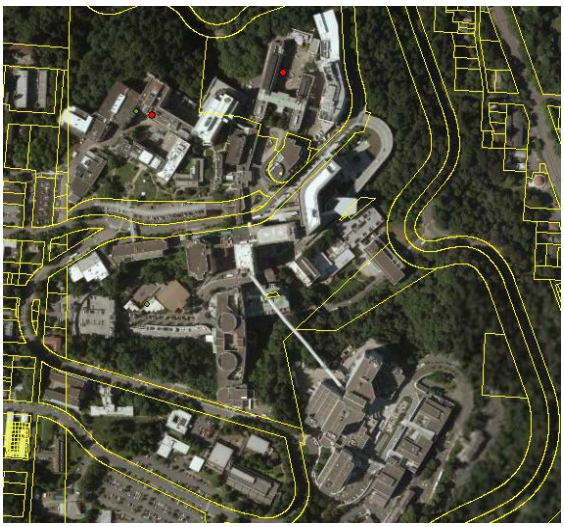
Geocoding Errors Due to Ambiguity or Errors in Address Source Data

- Address Data Errors: Large Campuses & Adjacent Lots

Development which occurred on sites comprised of multiple tax lots are the most common source of "inaccurately geocoded" error records. In these cases, the tax lots may have the same address, so the geocode may match a tax lot distant from the actual development.

This error was observed on both mid-scale developments and large multi-building campuses (e.g. high schools, shopping centers, hospitals, etc). Additionally, permits for large campuses may be issued with a central headquarters address as the site address instead of the building where development has occurred.
Because these records geocode to the general area of development, they are not considered severe. However, the presence of this pattern can yield problems in attempting to associate permit records to a specific tax lot or building.

Figure 13. Examples of real-world address ambiguity



14 permits for development on various buildings at OHSU all geocoded to one of two central locations highlighted in red in the image.

The permit for this development geocoded to the lot with the red dot instead of the lot with the primary development. In this example, the lots are reasonably compact and thus the geocode is not very far from the development location. In other cases observed, the geocode location can be quite far from the development because the lot sizes are much larger.

3. Address Locator Errors: Errors in locator data

The permit file was largely geocoded using the MAF_2008_Q2 locator using address information from 2008 tax lots A small number of permits were observed in which the permit address failed to geocode or geocoded to an inaccurate location. Manually matching of these records, however, using the current RLIS_MAF_juris_city locator, did match to the correct location. The difference in these cases can be traced to changes (presumably corrections) from the 2008 tax lots to the current tax lots. The number of these errors is estimated to be very low, however the error can be easily resolved geocoding with a current locator.

Figure 14. Examples of error in locator data

The highlighted permit geocoded to a street-level match because the 2008 tax lot file had an error in the site address. The permit matches the 2010 tax lot file and correctly geocodes with the current locator file.

Geocoding Evaluation Recommendations

Evaluation of the geocoding errors in the permits database reveals that these errors result from both problems in the permit database, problems with address data, and real-world address changes or ambiguity. Ambiguity in real-world addresses due to large or adjacent tax-lots is the most common cause of geocodes to a location that is not "on" the development site at the building or tax-code level. These errors are largely not resolvable. A smaller number of errors associated with unmatched permit records could be resolved through changes to the geocoding process:

- A small number of records which are now unmatched could potentially be match with additional pre-processing to filter for known street name errors (e.g. typos, and standardization errors.) The match improvement from this effort is estimated at roughly 500 to 1,000 records, or less than 1% improvement.

- A small number of older permit records which are now unmatched could be matched by using geocoding locator files created for the date of the permit records. The match improvement from this effort is estimated at a maximum of 300 records, or less than .1% improvement.
- A small number of records which are now unmatched or inaccurately geocoded could be improved by geocoding to a current address locator to capture tax lot site address corrections. The match improvement from this effort is estimated to be a few dozen records, or less than .1% improvement.