01 //

impact of slope on housing development costs

A report by the Center for Real Estate
Portland State University
For the City of McMinnville, Oregon

Lead authors

GERARD C.S. MILDNER, PH.D.
JERALD JOHNSON, AICP
ROBERT TRAPA, M.ENG

Research Team

JEFF HORWITZ
ALEXANDER WALLACE
TREVOR WRIGHT

Any errors or omissions are the author's responsibility. Any opinions expressed are those of the author solely and do not represent the opinions of any other person or entity.

One of the tenets of the Oregon land use planning system is that cities will develop within urban growth boundaries (UGBs), protecting farmland, forest land, and open space, and that those boundaries will maintain land supplies representing 20 years of population and economic growth. Within the real estate and urban planning professions, these definitions have been widely debated, with some arguing that urban development can become more dense and existing UGBs can support much greater densities, extending the protections on agricultural land and open space, with others arguing that dense development can only be supported by sufficient rents and prices and that the assumed carrying capacity of the land is less than it would appear.

The City of McMinnville, Oregon asked the Portland State University research team to investigate the impact of slope on housing development within its UGB. The city is located within the Willamette Valley and much of the land within its UGB has slope and other topographic constraints that require significant contouring, site stabilization, and infrastructure improvements in order to be developed. These additional site preparation costs add to the cost of developing the sloped parcels within the UGB, requiring premium selling prices and rents in order for the development to be feasible. And when these higher price points cannot be achieved, many of these parcels remain undeveloped and do not add to the effective 20-year land supply that the state statutes promise. Moreover, the yield of housing units per acre is greatly reduced when significant slope exists, as buildings need to have less mass and greater separation to avoid the problems of stormwater runoff and landslides.

These cost barriers create urgent problems for the development of affordable housing. Affordable housing requires low site preparation costs, as well as public subsidy, in order to meet the needs of low-income households within the community. When affordable housing developers submit applications for subsidy funds, they are often (correctly) judged by the cost of construction per housing unit. When site preparation costs are high, affordable housing developers won't be able to submit competitive grant applications.

In this report, we will segment the discussion by focusing first on the impact of slope on single-family housing development, followed by the impact of slope on market-rate, multi-family development, and then by the impact on affordable multi-family development. Data for the project comes from examples throughout the Willamette Valley, supplemented by construction cost information at a national level.

1. Single-Family Development
2. Market-Rate Multi-Family Development
3. Affordable Multi-Family Development
4. Conclusion

SECTION 1: SINGLE FAMILY DEVELOPMENT AND SLOPED LAND

As part of the update to its comprehensive land use plan, the City of McMinnville sought to understand the additional cost of developing land on sites with varying slope and soil conditions. This section of the report examines the additional cost associated with building single family home developments on varying slopes. This section of the report will evaluate the effects of building on flat (0-4% gradient), moderate (5-9% gradient), and steep slopes (10% gradient and up) in terms of construction issues, the cost of infrastructure construction, home value, and yield of homes in a given development.

To do this, developers and engineers were interviewed. Additionally, this section examines two separate data sets that seek to answer the questions above. The first data set consists of 16 single family developments in the Willamette Valley built by a developer located in Washington County. The second data set consists of 12 case studies of single family developments in the Willamette Valley on varying slopes built by four distinct developers.

CONSTRUCTION ISSUES RELATED TO BUILDING ON SLOPED LAND

There are several common construction-related issues that builders experience when building on sloped land. The most prominent issues that developers and engineers referred to were earthwork, including removing soil and building retaining walls, and storm water management. All of the people interviewed agreed that building on flat ground was less expensive than building on slopes; and when building on slopes, it is less expensive to build on a downhill lot (where the slope goes down from the front to the back of the home) than it is to build on an uphill lot.

One developer in Clackamas County estimated that downhill lots were, "20% to 25% more expensive" to develop than flat lots, while uphill lots were, "25% to 30% more expensive" than flat lots. A developer in Washington County mentioned that the value of a downhill lot is, "33% less than flat lots", while uphill lots could be as much as, "40% less" valuable. One reason for the difference is that it is easier to build foundations downhill than it is to carve them out of an uphill slope. It is also easier for a builder to move soil and rock downhill, away from the street – in order to make a lot flatter – than it is to move soil and rock uphill, toward the street.

Another earthwork issue related to sloped land, according to a project engineer from Multnomah County, is that sloped land has not experienced erosion and sedimentation as much as flat land has. Because of this, there is often less topsoil on sloped land, and the soil and rock that remains is often more dense than the soil on flat land. This makes it more expensive to excavate soil on slope than soil on flat land, for example.

In addition to physically moving earth, creating retaining walls and terracing requires extra labor and materials. One common way to build

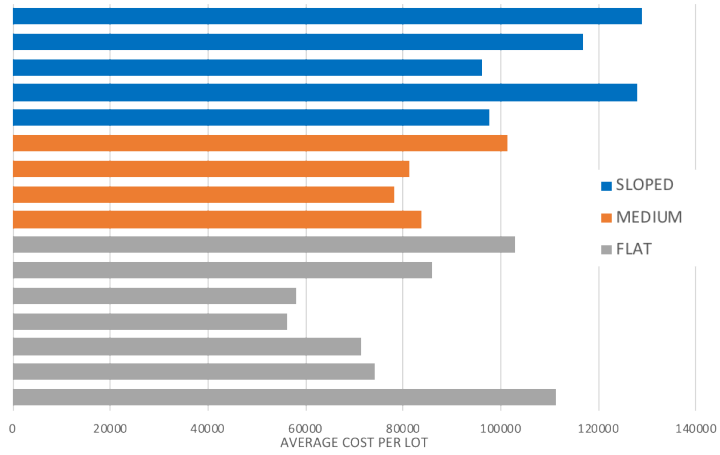
a retaining wall is using boulders. According to a project engineer in Marion County, when retaining walls and terraces start to exceed four feet in height, a builder can no longer use boulders for retaining walls and must use steel-reinforced concrete. The project engineer estimated that the additional cost of boulders was around $25/square foot, and the additional cost of steel-reinforced concrete could range anywhere from $50/square foot to $75/square foot.

Another construction issue that most of the developers brought up was the issue of storm water management. On sloped land, storm water runoff must be managed to avoid flooding and landslides. According to a developer in Washington County, it is also more difficult to do so on sloped land because, unlike a flat development, there are no natural land features to retain the storm water. This developer, who was working on a steeply sloped development, had to install an underground water retention feature connected to a water treatment system by a pipe that was seven feet high and 190 feet long. According to the project engineer in Marion County, although the cost of treating water is similar on sloped and flat developments, the initial capital expense is much greater for sloped projects.

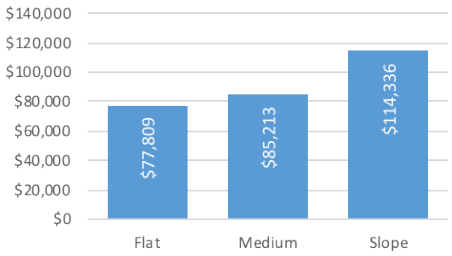
The yield of homes might also be considered a construction issue because of the infrastructure required to build homes on slope. In certain situations, homes must be single loaded on one side of the street if slopes are too great. Also, lots that are built on sloped land tend to be bigger to offset the effect of slope. In a sampling of 16 single family developments from a developer in Washington County with 328 total lots, the mean (average) lot size for homes on steeply sloped, moderately sloped, and flat developments were 4,800, 4,625, and 3,843 square feet, respectively. The median lot size for the same sample set were 4,500, 4,250, and 2,900 square feet, respectively. Five of these developments were built on steeply sloped land, four were built on moderately sloped land, and seven were built on flat land.

There were also a few minor issues that developers noted with some frequency. One of these issues was the expense of building road and sidewalk features to ADA accessibility standards. ADA standards require that all new developments have flat intersections, as well as sidewalks and curb cuts at gradients 8.3% or less. A developer in Multnomah County said that the most expensive part of ADA accessibility was ensuring that intersections are flat. Of course, many developers also recognized the importance of aligning a project's construction schedule to avoid working on any key steps in the process during the rainy season in the Willamette Valley.

LOT DEVELOPMENT COSTS BY SUBDIVISION

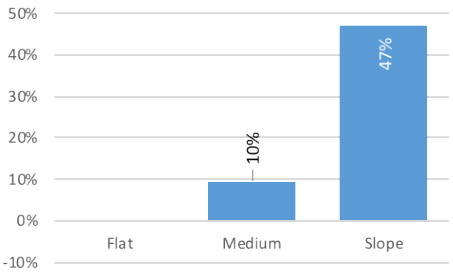


WEIGHTED AVERAGE COST/LOT



WEIGHTED AVERAGE COST PREMIUM

WEIGHTED AVERAGE COST PREMIUM



DATA SETS AND ANALYSIS

This section will draw upon two separate data sets to evaluate the effect of slope on infrastructure construction costs and home value. Data set #1 consists of 16 single family developments with 328 total lots, which were built throughout the Willamette Valley by a developer based in Washington County. Five of these developments were built on steeply sloped land, four were built on moderately sloped land, and seven were built on flat land. As discussed in the previous section, this data set illustrated that as slope increases, the yield of lots in a given development decreases. It will also show that as slope increases, infrastructure construction costs increase.

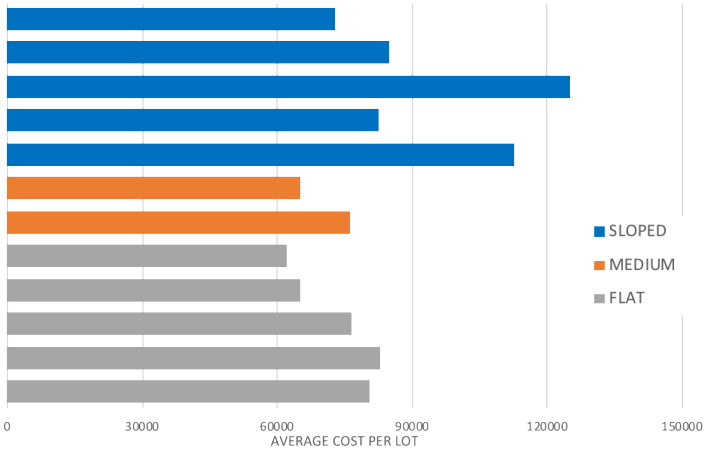
The mean infrastructure costs per lot for steeply sloped, moderately sloped, and flat developments in this data set was $114K, $86K, and $80K, respectively. Further, the median infrastructure costs per lot were $117K, $83K, and $74K, respectively. While the difference in infrastructure costs per lot between flat developments and moderately sloped developments is relatively small, the difference in costs between moderately sloped and steeply sloped developments appears to be approximately $28K to $34K per lot, based on the mean and median, respectively. The disparity becomes even larger when comparing steeply sloped and flat developments. In this case, the mean and median suggest that the difference is approximately $34K to $43K.

The following graphic summarizes total lot development costs by subdivision in this data set, broken out by degree of slope. The weighted average premium (adjusting for subdivision size) was 10% for a medium sloped property vis-à-vis a flat site, increasing to a 47% premium for a sloped site.

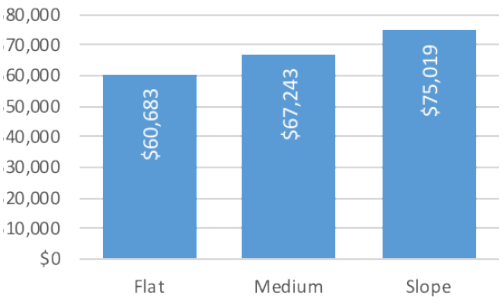
SUMMARY OF DATA SET #1

Data set #2 consists of 12 case studies of single family developments built by four separate developers. Five of these developments were built on steeply sloped land, two were built on moderately sloped land, and five were built on flat land. The mean per lot infrastructure costs for steeply sloped land, moderately sloped, and flat developments were $82K, $69K, and $62K, respectively.

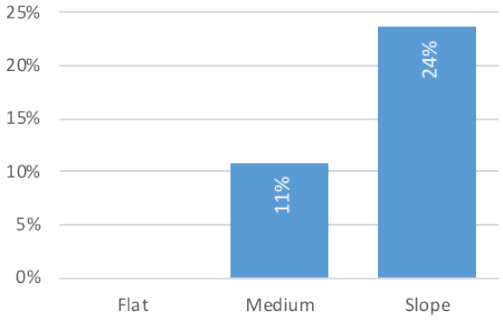
LOT DEVELOPMENT COSTS BY SUBDIVISION



WEIGHTED AVERAGE COST/LOT



WEIGHTED AVERAGE COST PREMIUM



The median per lot infrastructure costs for these developments was $75K, $69K, and $63K, respectively. In terms of this data, the mean per lot infrastructure cost for steeply sloped developments was $13K higher than moderately sloped developments, and $20K higher than flat developments. The median infrastructure cost for steeply sloped developments was $6K higher than moderately sloped developments and $12K higher than flat developments.

Three of the homes in data set #2 were built by a developer who builds luxury homes and were all over $1.0 million. One of these was built on slopes of 10% to 25%, and homes in this development range in value from $1.1 to $1.3 million. The two other luxury developments were built on flat land, and the home values in these developments range from $1.15 to $2.2 million.

The remaining nine developments in data set #2 have homes that range from $348K to $685K. Of these developments, four were built on steeply sloped land, two were built on moderately sloped land, and three were built on flat land.

The lot development costs by subdivision in this data set show a similar pattern to those in the first data set, with the weighted average development cost per lot increasing as slope increases. In this case, the cost premium for a medium slope was 11%, while a higher sloped lot had a premium of 24%. While the differential was somewhat lower in percentage terms, it remains significant.

SUMMARY OF DATA SET #2

The homes built on steeply sloped land ranged from $360K to $685K, the homes on moderately sloped land ranged from $420K to $620K, and the homes built on flat land were $348K to $635K. When looking at the higher end of these ranges, it appears that developments on steeply sloped land have the homes with the highest values; however when looking at the low end of these ranges, it appears that homes on moderately sloped land have the homes with the highest values. Based on this information, it is difficult to say how sloped land affects the resale value of homes.

SECTION 1 CONCLUSIONS

The purpose of this section was to evaluate the effects of building single family developments on flat, moderately, and steeply sloped land in terms of construction issues, the cost of infrastructure construction, and home value. The main construction issues posed by building homes on sloped land were earthwork, water management, and reduced yield of homes on a given development. In terms of the cost of infrastructure and home value, there are other variables that were not taken into account such as the soil quality, materials used in construction, and the varying expenses of building in different jurisdictions. While there is evidence that building luxury homes on sloped land decreases the value of those homes, it cannot be said conclusively what the effect developing sloped land has on home value. Based on the information gathered in this report, it can conclusively be said that as slope increases, infrastructure construction costs increase significantly.

Increased lot development costs directly impact housing prices, as homebuilders purchasing lots will need to recover those costs. The typical lot accounted for 26% of final home price for all sales recorded in the Portland metropolitan area in 2019. While there is a great deal of variability between subdivisions due to differences in achievable pricing by market and land purchase price, it is common for a developer to increase their pricing by a ratio of roughly four to one to recover the additional costs and maintain their margins. The two data sets evaluated indicate a cost premium for a sloped site of between $14,300 to $36,500 per lot. Assuming that the lot price remains at 26% of home price, this would indicate an increase in home prices of between $55,000 and $140,000 per unit.

It should be noted that the final home price is a function of what the market will bear, and the loaded cost of the lot is also a function of the purchase price of the undeveloped property. As a result, these ratios may vary significantly on an individual development basis. To the extent that the market can support higher final home prices, this additional value will typically be reflected in transferred lot price. The incremental increase in costs is therefore more easily dealt with in markets that can support higher home prices, with more affordable housing less capable of absorbing these costs. While sloped sites (up to 20-25%) can be successfully developed for higher end housing, they are unlikely to have the capacity to meet the full pricing spectrum of detached housing demand.

SECTION 2: MARKET-RATE MULTI-FAMILY DEVELOPMENT AND SLOPED LAND

The research team interviewed professionals at local real estate construction firms to learn about the challenges of constructing apartment projects on sloped sites. Sloped site development often results in a project incurring additional costs and extended schedules. Development impacts include complications with overall site logistics, installation of site utilities, water retention ponds, erosion control measures, site retaining walls, and more complex stepped building foundations.

Site logistics often hamper excavation since earthmoving equipment cannot easily access the sits. For example, sloped sites may require track mounted excavators rather than bulldozers and scrapers. In addition, concrete may be required to be pumped rather than deposited by a standard chute method and aggregate fill may need to be deposited by conveyor rather than using a typical dump truck deliver method.

Surface water runoff during construction, especially during the fall and winter rainy seasons, requires additional silt fencing, temporary water retention ponds, straw waddles and hay bales as well as diligent maintenance of these temporary erosion control systems. Additionally, as these sites are developed, terraced retaining wall systems are erected for end-user accessibility and most often building structure foundation walls are taller and have more robust waterproofing systems applied in order to keep subsurface water from entering the buildings.

Sloped site development may also require complex and costly deep utility trench excavation and shoring systems. Onsite lift stations are possible, but the pump and control equipment needed for these lift stations is costly and requires regular maintenance.

Typical development costs for no slope sites range from $16 - $25 per square foot. On moderately sloped sites, those less than a 10% slope, cost impacts can increase the project site development costs by as much as 30%. Consequently, the cost increase for the site development of a moderately sloped, a 5-acre parcel may range between $1,045,000 - $1,634,000.

On steep sloped sites (those greater than 10%), cost impacts can easily increase the project site development costs by 50% or more. As a result, cost increases for site development on a steep sloped 5-acre parcel may range between $1,742,000 - $2,723,000.

DATA SETS AND ANALYSIS

To better understand the underlying development costs on sloped sites, we reached out to numerous, local general contractors, design firms, and developers to develop two data sets that looked at site development costs and total construction costs. By contacting these various firms, we gathered detailed information on market-rate, multi-family development projects in and around the Portland metropolitan area. In particular, we looked for the timeline of the project (using either the bid date or the completion date), the slope grade of each project, the total development cost of each project in a lump sum, and the site-specific development costs removed from the total project cost.

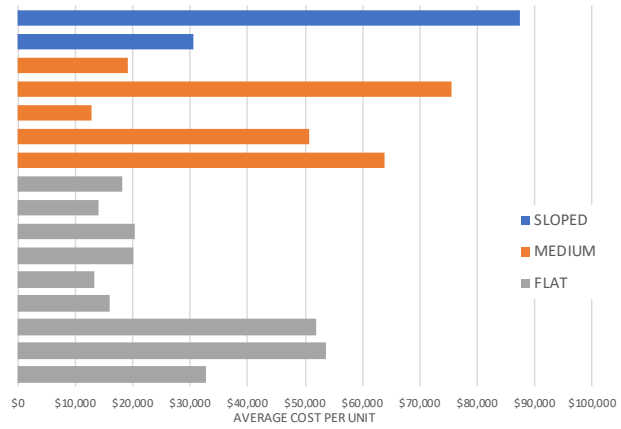
Seeking cost information for multi-family developments in the Portland metropolitan area from private firms proved to be difficult. Much of this information is confidential and important to maintaining a competitive business, so attempting to extract this information for outside research purposes was difficult. Even more difficult was getting in contact with the right personnel from each firm. Many of these firms were very busy, and the work required to extract this data is essentially extra, unpaid work for these firms. As such, in the process of gathering the data, we were unable to obtain some of the key pieces of information outlined above due to time constraints.

Another aspect of this process was converting development costs to present-day dollars in order to better compare the different developments. In this sense, it required finding the original dollar costs of each project and then adjust those costs for inflation using an inflation index dedicated to construction costs. In some cases, the providers of the data adjusted the costs to present-day dollars for convenience, but they used a different index than the one that was chosen for the project (the Seattle ENR City Cost Index). This inconsistency required going back and extracting the original data in order to adjust it with the same index as the other projects.

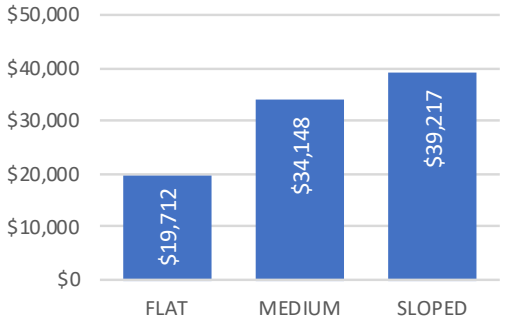
For example, one contractor provided data on completed multi-family development but was unable to extract site-specific development costs due to time constraints. Wherever possible, we attempted to fill in gaps for the key information pieces. One set of data did not provide site-specific slope grades, which required us to locate each project and determine slope grade using various mapping software.

In addition to gathering cost data, some supplemental work involved analyzing potential sites for development in McMinnville in order to determine soil anatomy. Gathering this information will ideally provide a convenient file of basic soil information for each site for future reference. Upon looking further into the soil anatomy to determine foundation requirements specific to each site, we determined that a truly useful opinion of value on foundation requirements can only be derived by an actual on-site analysis in order to get a full understanding of the soil conditions. However, researching general foundation and soil conditions, we managed to come to a general conclusion on the viability of the development on the potential sites.

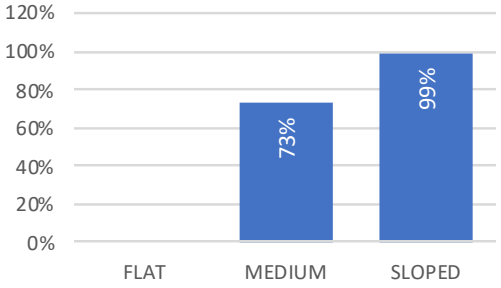
PER UNIT SITE DEVELOPMENT COSTS BY PROJECT



WEIGHTED AVERAGE COST/UNIT



WEIGHTED AVERAGE COST PREMIUM



After putting the data together on development project costs, the data was sorted according to three categories: 1) Site Development Cost/Site Area; 2) Total project construction cost/Site Area; 3) Total Project Cost/Unit.

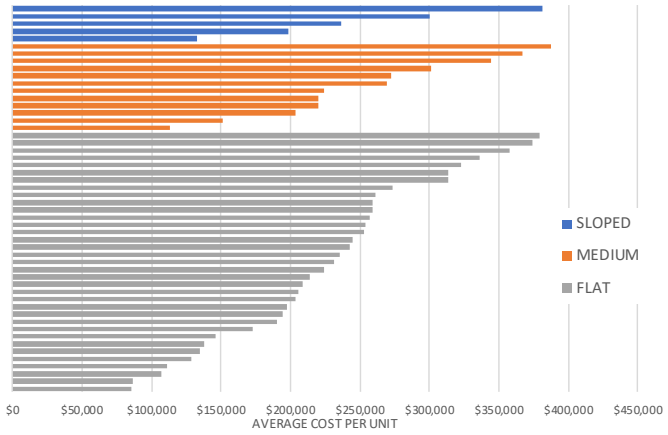
Upon sorting the data based on these units of comparison, projects with numbers that grossly exceeded the average number range of the data set were thrown out to better focus the comparison between the most similar projects. After examining the reduced data set, we found significant variation in costs, both between the categories based upon slope, as well as within those categories, given the wide variation in location, unit size, and construction type.

From this data, we found nine observations with mild or no slope (0-4%), five observations with moderate slope (5-9%), and two observations with steep slopes (10% or higher). From these observations, we computed the weighted average site development cost and found the steep sites required $39,217, the moderate sloped sites, $34,418, and the mild/no slope sites $19,712. Put differently, moderate slopes added 73% to site development costs relative to flat sites, and highly sloped sites increased site development costs by 99%.

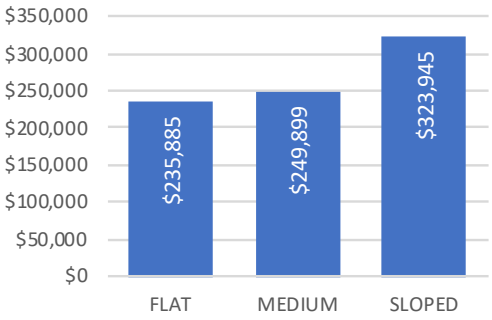
SUMMARY OF DATA SET #3

The research team had more information on total project costs, with five projects built on highly sloped sites, twelve projects built on moderate slopes and thirty-five projects built on mild slopes or flat sites. From these observations, we computed the average project cost per unit weighted by the number of units and found development costs of $323,945 per unit for highly sloped sites, $249,899 for moderately sloped sites, and $235,885 for mild slope or flat sites. Put differently, the total project cost per unit of moderate sloped sites required a 9% premium over mild slope or flat sites, and highly sloped sites required a 37% cost premium over mild slope or flat sites.

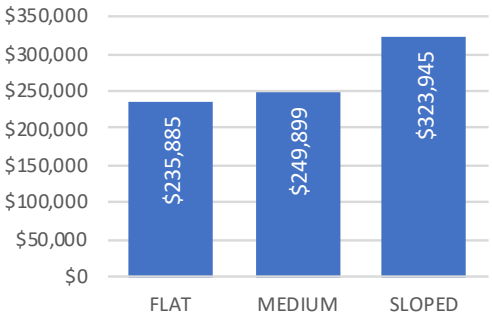
TOTAL CONSTRUCTION COST PER UNIT BY PROJECT



WEIGHTED AVERAGE COST/UNIT



WEIGHTED AVERAGE COST



SUMMARY OF DATA SET #4

As can be seen from the table above, there are many more multi-family development projects that are built on sites with little slope. While there are construction strategies for handling slope, those strategies are expensive and those sites either require a premium rent or remain undevelopable. For that reason, sloped sites are often overlooked in favor of easier-to-develop sites with mild or no slope.

SECTION 2 CONCLUSIONS

Slope and terrain remain a barrier for market rate developers. As discussed above, construction firms need to employ expensive construction techniques to excavate sites. Concrete often needs to be pumped uphill, and aggregate may require conveyor systems to deliver material where its needed. Construction firms will need more extensive retaining walls and terracing to keep their sites stable. Installing utilities and other infrastructure is also a complication with slope sites, including the management of storm water runoff and retention.

SECTION 3: AFFORDABLE HOUSING AND SLOPED LAND

The goal of this section was to determine if sloped sites had an impact on construction and development costs of affordable housing. To collect the information required for analysis, outreach began to affordable housing developers based in Oregon, with specific focus on projects built along the corridor of I-5 from Portland to Eugene. Oregon Housing and Community Services provided some starting data on projects around Oregon, and Home Forward, as well as the Housing Development Center, each provided projects in their pipeline or those that they had finished fairly recently. Other affordable developers provided data on several projects, though often neglecting to share full development or construction costs due to privacy concerns or an unwillingness to scour through their old projects for those that featured slope.

Nearly every affordable housing developer did not internally differentiate or specify their projects that were built on sloped sites, and it was often first-hand knowledge of a specific site that led to information being shared. Notably, many affordable housing developers stated outright that they do not build on sloped sites, or that developing on a sloped site is a very rare phenomenon, as it is assumed that slope would bring an additional cost to development. This posed an interesting problem for the analysis in terms of being able to collect data on sloped sites, where few appeared to exist. Additionally, several developers were willing to offer quotes for the analysis based upon conditions of anonymity:

"What we all already know, it's a lot cheaper to build on flat land rather than steep slope."

"There is an additional cost burden which sloped sites cause for such projects."

As the project was a comparison of costs based upon slope, information was collected on projects built both on sloped and flat sites as well as the gradient each site featured. Using the data provided by OHCS as a starting template, projects were defined by their location, the year they were finished, their square footage, and the total number of units in each development. Dollar amounts for total construction and development costs for each project were collected. These costs were then adjusted for inflation based upon the year they were built and using the Seattle ENR City Cost Index to bring their costs up to their value in 2020 dollars. These adjusted totals were then used to calculate construction and development costs based upon the site area, as well as total project cost per unit.

Once data was collected, an analysis was conducted to establish the impact sloped sites had on affordable housing development costs versus those built on flat sites. The data collected revealed that as slope increased, sites that featured a 20% slope gradient or above reflected higher development costs (between 40-50%) in comparison to the project's construction costs. Sites with less slope - those with

7.5% gradient or below - saw little to no impact on their development costs in comparison to sites built on flat ground. Additionally, sites that featured any gradient of slope tended to have slightly higher development costs per square foot than flat sites. Sites built more recently, those within the last 2 years as well as those currently in development, tended to feature higher costs overall regardless of their slope.

SECTION 4: OVERALL CONCLUSIONS

Land is an essential component of real estate development, and there is much variety in the quality of sites. Historically, cities developed near water ports and railroad lines, both of which tend to accommodate or require flat sites. Development tends to follow river valleys and expensive uphill transportation is avoided. As regions become congested, developers are often left to consider sloped sites, given the tendency of flat sites to be already developed. And in Oregon, our land use planning system encourages greater consideration of sloped sites inside urban growth boundaries, as the lack of available flat sites causes land prices to rise.

The research team was able to find a mix of single-family and multi-family development projects that were built on a variety of slopes. For single family development, slope sites require terracing that involves boulders or retaining walls with steel-reinforced concrete, so that individual homeowners can have relatively flat yards. In addition, slope sites require excavation and moving earth with expensive equipment. And the development of water retention ponds is complicated by sloped land, sometimes requiring underground piping systems and pumps.

In addition to interviewing construction firms and single-family development companies, we constructed two data sets to measure the impact of these additional expenses on development costs. We found that adding slope to the site led to an increase in development costs by 10% to 47% and subdivision development costs rising between 11% and 24%, depending upon the severity of the slope. These increases in development costs lead to higher prices for homeowners. And the added complexity of development on sloped sites also leads to smaller yields of housing units for a given acreage of the site. That may result in a lower density of housing units per acre, or unless achievable prices are high, no development at all.

For multi-family development, the construction challenges are magnified due to the weight of the buildings and the greater risk of settlement and landslides. We found additional problems resulting from waterproofing basements from subsurface water. Delivery of concrete and aggregate often require pumps and conveyor systems, respectively. And sloped sites experience greater challenges with water runoff and the construction of water retention systems.

Professionals in the industry advised us that moderate sloped sites could result in additional costs of $1.0 million to $1.6 million for a 5-acre site, and steep slopes would result in additional costs of $1.7 million to $2.7 million for such a site. To assess this question further, the team

constructed two data sets of recently built apartment projects, adjusting those cost figures for inflation. We found an increase in site development costs ranging from 73% to 99%, depending upon whether the slope was moderate or high, leading to overall construction costs to rise between 6% and 37%, respectively.

These increases in costs create particular challenges for affordable housing developers, who depend upon a variety of funding sources and don't have the reserves to obtain and land bank flat sites for future development. Moreover, they are not able to capture the premium rents that development on sloped sites require. Given these challenges, cities need to insure a robust supply of relatively flat land to encourage the development of affordable housing.

THE RESEARCH TEAM

GERARD C.S. MILDNER is an Associate Professor Real Estate Finance at Portland State University and the Academic Director at the PSU Center for Real Estate. He has a bachelor's degree from the University of Chicago and a Ph.D. in Economics from New York University.

JERALD JOHNSON is a principal with Johnson Economics and an Adjunct Instructor in Real Estate at Portland State University. He has bachelor's degrees in Architectural Design and Economics and a master's of Urban Planning from Portland State University.

ROBERT C. TRAPA is a Senior Vice President with Bremik Construction in Portland and an Adjunct Instructor in Urban Studies and Planning at Portland State University. He has a master's degree in Engineering Management from Montana State University

JEFF HORWITZ is a master's degree candidate in Real Estate Development from Portland State University and is the RMLS Student Fellow with the Center for Real Estate. He has a master's degree in Urban Planning and Policy from the University of Illinois at Chicago.

ALEXANDER WALLACE is a master's degree candidate in Real Estate Development from Portland State University and is an SCS Student Fellow with the Center for Real Estate. He has a bachelor's degree in Law from the University of Stirling in Scotland.

TREVOR WRIGHT is a master's degree candidate in Real Estate Development from Portland State University and is an SCS Student Fellow with the Center for Real Estate. He has a bachelor's degree in History from the University of Oregon.