

CHANGES IN FLOODPLAIN OCCUPANCE

PORTLAND, OREGON 1957 - 1986

by

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## CHANGES IN FLOOD PLAIN OCCUPANCE

PORTLAND, OREGON 1957 - 1986

**ABSTRACT:** Portland, Oregon is in the northern end of the Willamette River Basin and Valley. The Willamette River carries the runoff discharge from approximately 12,000 square miles of basin area, and flows northward where it bisects the Portland metropolitan area and enters the confluence with the Columbia River. However, high discharge rates in the Willamette are seldom the cause of flooding in this area. Elevated flood crests in the Columbia create backwaters in the confluence area, which are the prevalent cause of most severe flooding events in the Portland area Willamette floodplains. Upstream storage has reduced the flood crests of both rivers. The Columbia's reduction contributes most to Portland area flood-related problems, while the Willamette's upstream storage contributes mostly to a significant improvement in water quality in the Portland area. In 1957, Gilbert White conducted a study of the urban flood plain occupance in Portland to determine if any occupance patterns emerged as a result of the 1936 flood control legislation. Some of White's data, methods, and occupance classification guidelines are used (with some modifications) to account for some of the changes that have occurred since 1957. The purpose of this paper is to conduct a similar study centered around the era of legislation enacted from 1968 to 1973; specifically the National Flood Insurance Protection Act of 1968, and the Flood Disaster Protection Act of 1973. The 100-year regulatory elevation was established in the 1973 legislation to use as a floodplain management tool by local governments. This study investigates the hypothesis that noticeable floodplain occupance patterns will emerge as a result of those floodplain regulations. The basis of comparison is the occupance data during the time period 1957-1972, compared with changes occurring from 1972-1986.

## INTRODUCTION

The Willamette River Basin is a 150 mile long by 30 mile wide trough-shaped valley containing an area totaling approximately 12,000 square miles. Approximately 93 per cent of the basin is drained by the Willamette and its tributaries. Approximately 70 per cent of the state's population resides within this basin, and the major cities of Portland, Salem, and Eugene are situated directly along the Willamette's riverbanks.

The city of Portland lies along a portion of the northern border of Oregon situated near the confluence of the Columbia and the Willamette Rivers in the northernmost edge of the Willamette River Basin. The city is bisected into eastern and western sections by the northerly-flowing Willamette River.

It is a large and active seaport with additional transportation, timber, fabrication, and manufacturing industries. Most of the industry is "river-oriented", i.e., those which use transportation other than waterways, and are sited on the riverbank areas to take advantage of grade or other benefits found on the flood plain (White, et al. 1958,54). The city's central business district and the majority of the industrial areas are on the west bank, while the east bank consists of roughly 75 percent residential dwellings. Very little of the city lies on the flood plain, but the majority of the central business district, and the industrial areas are within the boundaries of the flood of record (White, et al. 1958,164).

## FLOODING AND HYDROLOGIC CHARACTERISTICS

### Flooding Characteristics and Events

Flood crests on the Willamette, generally reach their highest elevations during the heavy runoffs of late fall and winter ( The pre-1954 mean, yearly average was 23,000 c.f.s., measured at the Salem gaging station - Gleeson 1972).

Corps of Engineers impoundments constructed on the upper tributaries of the Willamette have reduced the winter flood crests. It is estimated that peak discharge regulation on the Willamette peak saved approximately 500 million dollars in damage that

would have otherwise occurred during the 1963-64 flood events (Gleeson 1972).

However, it is the adjacent Willamette-Columbia confluence which plays the key role in most of the flooding history of the immediate area, and it is the backwater from the Columbia that is responsible for most of the damaging floods on the Willamette River in the Portland area (reaching as far as Willamette Falls, in Oregon City). According to White, "All major flooding in and near Portland is related to the Columbia River...Flooding from the Willamette alone causes little or no overflow damage." (White, et al. 1958).

ok, but...  
White made this  
statement prior to  
the severe 1964  
floods. (The Willamette  
did contribute significantly  
to this one).  
Gleeson

The more frequent, and damaging flood crests from the Columbia occur primarily as a result of snow melt and spring freshets, which usually occur in May or June. The major flooding events in the Portland area illustrate this point; three of the four recorded major flooding events occurred during the month of June in 1894, 1948, and 1956; the other less severe flood occurred in December 1964.

During the three June events, the nearest reliable gaging station at the Dalles, Oregon recorded the peak discharges of 1,240,000 , 1,010,000 and 823,000 cubic feet per second (c.f.s.) respectively. The significance of these discharge rates is realized when one considers that major flood damage occurs in Portland with flows of 600,000 c.f.s. or greater (Flood Insurance Study. FEMA 1986).

Water Quality

Since the turn of the century, pulp and paper industries and municipal wastes have created serious pollution problems in the Willamette, particularly in the section of the river downstream from Oregon City. Part of the problem lies with the low summer discharge rates. During the summer months, the Willamette's flows are about one-tenth the volume of the winter discharge (The statistical average minimum flow prior to 1950 is estimated to have been 3,480 c.f.s. - Gleeson 1972). Much of the pollution has been abated with the construction of the C.O.E's reservoirs. These impoundments store much of the high runoffs during the the winter, then later release them to augment the low summer flows. Since the 1950s, these releases have nearly doubled the Willamette's previous summer discharge rates, and helped prevent polluted water concentrations from becoming worse. Flow

augmentation increased to the point where the "River readings showed approximately 6,000 c.f.s. Salem gage in 1953 and 7,000 c.f.s. in 1954." (Gleeson 1972).

However, the sources of pollution did not significantly decrease during the 1950s, and the benefits of flow augmentation were not appreciably noticeable until the next decade. Increased storage area, and tighter pollution controls had greatly improved the water quality in the late 1960s, and early 1970s (Gleeson 1972). According to the Oregon Department of Environmental Quality, the dissolved oxygen levels in Portland Harbor have remained above the standard of 5 parts per million for every summer since 1969. The improved water quality and aesthetic appeal has subsequently encouraged water-based recreation and increased the desirability of river frontage property. By the 1970s, it was "tentatively concluded" that the "amenities associated with waterfront locations more than offset both flood related apprehensions and whatever negative impacts floodplain regulations might have had." (Muckleston 1983).

## FLOOD HAZARD MITIGATION - PROTECTION AND PREVENTION

### Structural Flood Mitigation

Structural flood control projects have helped reduce some of these flood damages in one of two ways. Earlier methods of flood prevention diverted flood waters with dikes, levees, and seawalls by forming barriers between the water and the protected area. This method prevented or reduced the actual contact with the water at the desired site, but it did not reduce the volume of the floodwater, and the flood extent in surrounding areas intensified. The sandbagged Portland seawall (constructed in 1928), extending from the Steel Bridge to the Hawthorne Bridge, prevented much of Portland's central business district from flooding during the 1948 flood. However, it did not prevent extensive flood damage in other nearby areas along the Willamette flood plain.

Subsequent dam and reservoir projects which have been constructed on the Columbia and the Willamette have retained large volumes of water during high runoff periods, and released them during the lower flow periods. According to a recent study by the Federal

Emergency Management Agency (FEMA), "The Columbia River Basin includes 22 major reservoirs with a total flood-control storage volume of approximately 40 million acre-feet. ...The Willamette River Basin has 11 major flood-control reservoirs with approximately 1.7 million acre-feet of flood storage..." (FEMA, 1976). This method has reduced the flood crests of the rivers, thereby reducing the amount of area subjected to flood hazard during the high runoff periods. In the Columbia, this method provided a significant reduction in the May and June flood crests and substantially reduced the flood hazard in Portland flood plains. In the Willamette, storage contributed to winter flood crest reduction, but was more effective for its role in improved water quality .

Floodproofing is a different form of structural flood hazard mitigation. Rather than attempting to physically prevent the water contact with the building, this method incorporates engineering construction concepts that allow a building and its contents to withstand the contact with flood waters without experiencing serious damage. It generally involves two categories of design; one is a flow-through concept which allows flood waters to pass benignly through the ground level of a building. These flow-through spaces are generally reinforced concrete, and are not used for any purposes which would expose susceptible equipment or furnishings. The second method involves reinforcing and waterproofing the lower levels of a building to prevent water from entering and damaging the contents. Both methods are designed as protective measures against the rare inundation event in those areas of considerable distance from the natural floodway. Their effectiveness rapidly diminishes with increased exposure to the strong currents found near the floodway.

#### Nonstructural Flood Mitigation

For several decades after passage of the Flood Control Act of 1936, it became increasingly evident that heavy investments in structural methods of flood hazard mitigation were not sufficient to reduce the increasing costs of benefits to flood victims. White stated, "While expenditures for flood protection and abatement continued at a high level, public contributions to relief and rehabilitation of sufferers from flood disasters also remained high and were supplemented by new forms of aid." (White, et al. 1958, 24). Federal

budget departments warned of increasing costs to taxpayers for flood-related damages. A cooperative state-Federal flood insurance program was underwritten by the Federal government and authorized in 1956, but was never initiated due to lack of Federal funds (White, et al. 1958).

In the mid 1960s, flood plain management legislation began to solidify and take shape. President Johnson endorsed *A Unified National Program for Managing Flood Losses - H.D. 465* (authored principally by Gilbert White) in 1965, followed closely with *Executive Order 11296* in 1966. Both actions encouraged the continuation of efforts to reduce flood losses and increased the emphasis of wise land use management practices. E.O. 11296 stated "future Federal expenditures for flood protection...shall, as far as practicable, preclude the uneconomic, hazardous, or unnecessary use of flood plains in such connection." Lack of implementation was a serious setback to both actions, but they provided a foundation for continuing actions such as *The National Flood Insurance Act of 1968* (P.L. 90-448).

#### PURPOSE OF THE STUDY

The primary purpose of this study is re-examine a portion of the area which was investigated by Gilbert F. White in 1957 (White, et al. 1958). Secondary purposes will be to (1) determine the possible effect of recent flood plain regulation upon floodplain occupancy, and (2) to provide a continuing basis of comparison compatible with that of White's 1957 study.

White's study had two aims. The first was "to classify the urban flood situations in such fashion as to make possible meaningful generalizations about them... The second aim was to measure the actual changes which took place in the occupancy of selected flood plains in the two decades following the enactment of the national flood control legislation in 1936." At that time, White pointed out that there were vigorous public agency efforts to promote "flood abatement, flood protection, the forecasts necessary for emergency measures, and relief assistance." He continued with, "They have not yet practiced insurance measures, have made only minor efforts to directly affect land use in the flood plains, and have had little or no direct part in promoting land elevation and structural adjustments." (White, et al. 1958, 20).

White's study examined evidence from the entire U.S., including the Portland urban area. Some of the findings from his study are as follows: "Land elevation is a popular method of flood damage reduction because dredging of the harbor makes an abundance of fill available at comparatively low cost. Much of this filled area has already been developed." White further discovered that the Portland floodplain occupancy pattern "has shifted only slightly since 1936; the major changes being a decrease in commercial use and an increase in industrial units. Many commercial structures were recently removed in order to construct modern freeways and the approaches of two new bridges across the river." (White, et al. 1958, 168).

Legislation, and Portland's floodplain occupancy have both continued to change since the publication of White's study in 1958. This paper examines a nearly 30-year period which begins with the completion of Dr. White's study, and continues until 1986.

There are two separate legislative acts which have particular significance for their role during the more recent flood plain legislation. The first is the National Flood Insurance Protection Act (NFIP) in 1968 (P.L. 90-448). The other significant act is the Flood Disaster Protection Act of 1973 (P.L. 93-234). Both legislative actions occur near the middle of the study period and bisect the total time period under this investigation. The two periods of comparison are 1957-1972 (pre-regulatory) and 1972-1986 (post-regulatory). They are explained in more depth in the following section.

## SIGNIFICANT TIME PERIODS

### 1957 TO 1972

This period is referred to as the "Pre-Regulatory Period". There were several legislative actions dealing with various flood control methods, but none had any flood plain regulation.

Several federal programs attempted to refine the past strategies (prior to 1957), and further reduce the flood hazards. The *Flood Control Act of 1960* (P.L.86-645) provided funding for the Corps of Engineers to identify flood-prone areas and to disseminate engineering advice for flood hazard planning to non-federal jurisdictions.

In the late 1960s, federal legislation began to broaden the strategies to include land use control in flood prone areas. Although these first regulations demonstrated progressive thinking, they were controversial and ineffectually implemented. In 1965, *A Unified National Program for Managing Flood Losses* (HD 465), began a trend of increasingly broadened approaches including the proper management of floodplain development. However, these have also met with significant resistance and further refinement was indicated.

The National Flood Insurance Protection Act of 1968 was enacted under Title XIII of the Housing and Urban Development Act of 1968 (PL 90-448) and has two major purposes: (1) to offer insurance at subsidized rates to present flood plain occupants, and (2) to discourage future unwise development of the flood plains. To qualify for the federally subsidized insurance coverage, an appropriate local government body must have enacted adequate flood plain regulations according to FIA floodplain management standards.

#### 1972 to 1986

In April 1972, during this "Post-Regulatory Period", the city of Portland adopted ordinance 134486 which authorized and established its participation in the NFIP. Nonstructural measures such as review of appropriate building permit applications, subdivision proposals, and management of storm runoff were implemented. By September 1972, a total of eleven Oregon counties and 10 cities applied, and qualified for coverage. Multnomah county and the city of Portland respectively, were among those that qualified.

Nationally, however, the act contained several weaknesses. Many communities failed to participate because of the voluntary participation aspect and from pressures exerted by the development-oriented organizations. Flood insurance salesmen were also discouraged from participating because of the relatively low profit potential. Numerous other changes and amendments were added, and they in turn added to the confusion. The resultant general lack of support by the implementing agencies further prevented this act from becoming an effective land use control or flood hazard mitigation instrument.

The Flood Disaster Protection Act of 1973 (Public Law 93-234) closely followed the National Flood Insurance Protection Act of 1968, but it also provided stronger incentives for participation in the flood insurance program and land use controls in flood-prone areas. The incentives were double-edged; if the communities participated in the program, property owners would be eligible to purchase flood insurance at a low rate of 25 cents per 100 dollars worth of coverage in most areas, with the government paying the rest of the cost (approximately 90 percent). Without this insurance, the residents of flood-prone areas would be unable to obtain federal or federally-assisted loans for new construction or mortgages on existing buildings.

Although the 100 year flood plain concept had been conceived much earlier, the act of 1973 utilized the concept as a regulatory tool to promote wise use of the floodplain. The implementation of the regulatory 100-year flood elevational boundary was a significant factor which theoretically would produce noticeable (and desirable) changes in the type and site of newer developments.

#### THE FLOOD PLAIN: DEFINITION AND USES ALLOWED UNDER THE NFIP

Simply stated, the flood plain is that land surface adjacent to a river, stream or water-course which is usually dry during some seasons of the year, but may be subject to inundation by periodic floodwaters. The extent of the floodwaters, and their frequency, represent two critical questions which need to be addressed by those attempting to manage the flood plains.

An illustration of the basic flood plain concept is shown in figure 1. Flood plain regulations restrict development on the floodway itself, or the adjacent floodway fringe. Both are within in the "Regulatory", or "100-year" limit (zone "A"). The "B" zone indicates "Areas which are between the limits of the 100-year and the 500-year flood; or certain areas subject to 100-year flooding with average depths less than one (1) foot or where the contributing drainage area is less than one square mile; or areas protected by levees from the base flood." (Flood Insurance Rate Map - Portland, Oregon 1982). The "C" zones are those areas of minimal flooding.

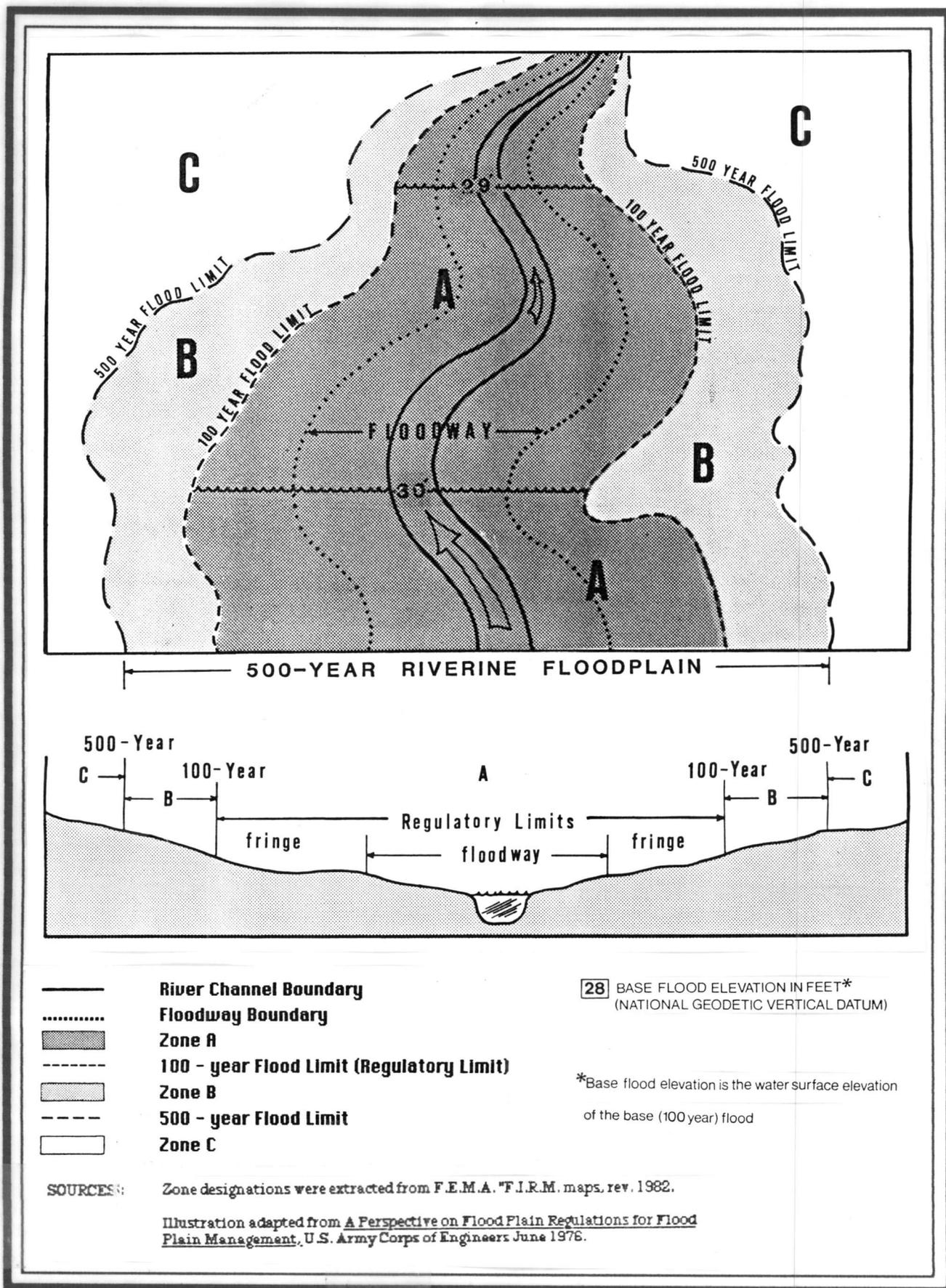


Figure 1.

Delineating the regulatory flood plain is a difficult and an arbitrary procedure. The principle of the regulatory limit is probably not as confusing or controversial as are the methods which were used to determine it. Many Federal Agencies have defined the regulatory floodplain as that area which is covered by flood waters that have an average recurrence interval of 100 years, i.e., having a one percent chance of occurring in any single year. Historic records of discharge and flood levels are used to determine the discharge of a flood of a particular frequency and comprise the fundamental element for the determination of the 100-year elevation. However, a number of other factors alter the discharge rates and frequency, tending to confuse the procedure. An example is a structural project by the Corps of Engineers which would lower flood crests and would also tend to lower federal regulatory levels. A continued record of substantially reduced discharge/frequency rates may serve to lower the regulatory elevation of the present 100-year level.

A map by the Portland Bureau of Planning indicates the areas designated as being within the 100-year flood plain (darkened areas. Figure 2 ). This map does not show the other characteristics of the flood plain, and the subdivision of zones within, as do the Federal Insurance Rate Maps, or "FIRMS". The numbers on figure 2 represent the specific study sites of this report. They indicate the relationship of the 100-year limit to the individual study areas.

#### THE STUDY HYPOTHESIS AND METHODOLOGY

National Flood Insurance legislation, particularly the NFIP in 1968, and the Flood Disaster Protection Act in 1973, required the Portland community to adopt and enforce several substantial floodplain land use requirements and restrictions. If these regulations have been effective, one should be able to observe an appreciable change in the land use patterns in the floodplain zones from the "pre-regulatory" (1957-1972) period, compared to those of the "post-regulatory" (1972-1986) period. Aerial photographs from 1957, 1972, and 1986, supported with field checks and historic data, should provide sufficient information to make a comparison between the two study periods. Quantifying the data may also help to identify the degree of any significant changes in land use categories.



Fig. 2

### Study Sites

Four study sites were examined for the purpose of this research ( Fig. 4). Three of the sites are on the east bank of the flood plain, and one is on the west. The sites were chosen partly because of known development activities in the area, and partly from the individual site characteristics as illustrated on Flood Insurance Rate Maps (FIRM 's) published by the Federal Emergency Management Agency. These rate maps illustrate the flood hazard zones of the floodplain.

### Data manipulation and analysis

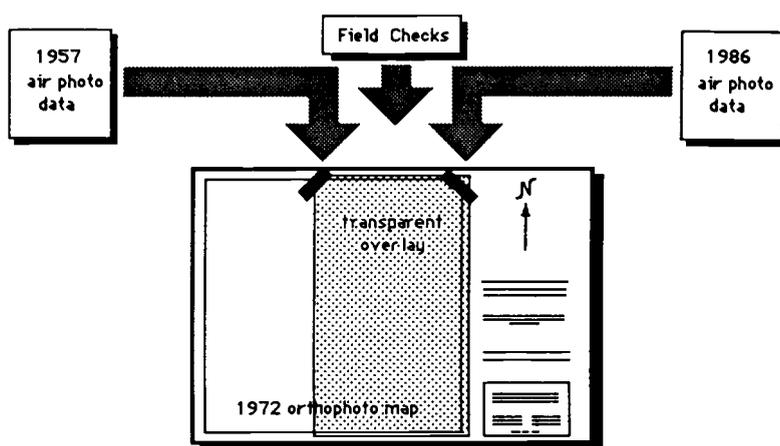
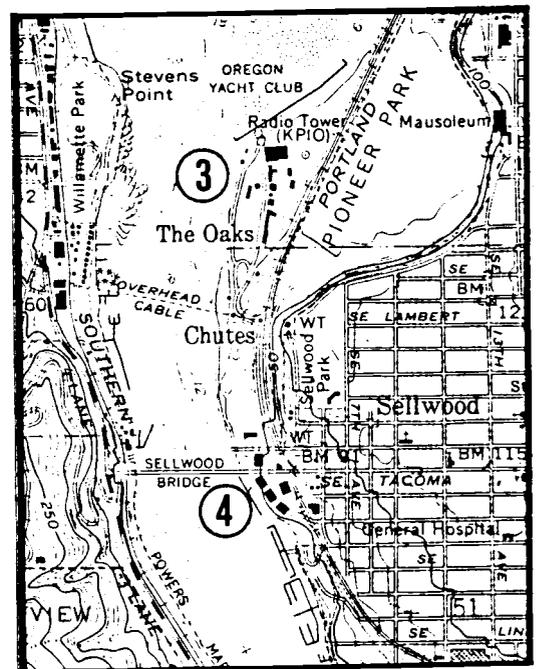
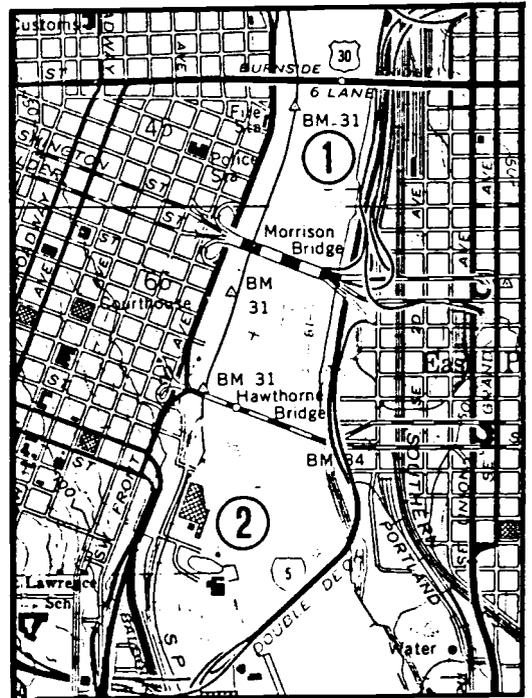


Fig. 3

A transparent overlay was placed over each of the individual study areas on the large scale orthophoto maps (1972). The existing structures were visually extracted from the 1957 and the 1986 air photos, then transferred to the overlay medium (fig.3).

Information regarding the changing occupancy during the first period was obtained primarily from the 1957, and 1972 air photos. It was supplemented with information obtained during field checks and document research in libraries and government agencies. Information regarding developments taking place from 1972 until 1986 were derived from the most recent air photos, also supported by field checks and agency documents. Standard methods of photo interpretation and comparison were used to transfer the information from the 1957 and 1986 air photos onto a common scale (1972) overlay. Measurements were made from the convenient 1" = 100' scale of the 1972 orthophoto base maps whenever possible. Actual dimensions of structures for 1957 and 1986 were determined by comparison with existing structures shown on the large scale orthophoto maps of 1972, and by information obtained during field investigations. Color codes and line symbols were used to differentiate



**FLOOD PLAIN STUDY SITES  
PORTLAND, OREGON**

① Burnside	③ The Oaks
② RiverPlace	④ Sellwood

FIG. 4

between dates and alternating changes in land use for purposes of interpretation and analysis purposes, but were unsuitable for black and white reproduction methods. Therefore the overlays have not been included with this report. Information for the maps used in figures 5, 6, and 7, was taken from sections of FEMA Flood Insurance Rate Maps, to illustrate the flood zone classifications and the specific study sites. Once again, the complexity of the changes shown on the photos for 1957, 1972, and 1986, prevents specific illustration in a single map. Therefore, only the major features and those individual sub-areas which underwent the most significant alterations within each site are identified separately.

### Tabulation

It appears that some land use changes have created the need for new or modified methods of tabulation. The necessary changes are listed below.

\* One structural unit is defined for the different occupancy classes as follows:

Residential - A.	A single or double-family dwelling. (per 10,000 square feet).
Residential - B.	A multi-family dwelling for 3-6 families (not used in this study).
Residential - C.	A multi-family dwelling for more than 7 families (per 10,000 square feet)
Commercial Bldg.	A separate store, office, or warehouse building. Structures count one unit for each multiple of 10,000 square feet of ground space.
Industrial Bldg.	A separate building, exclusive of small auxiliary buildings. One unit for each multiple of 10,000 square feet of ground space.
Transport Bldg.	One unit for each multiple of 10,000 square feet of ground space.
Trans./Ind. Open.	Combination of Transportation and Industrial open spaces. One unit for each multiple of 10,000 square feet of ground space. ( <u>Private Ownership</u> ).
Public Building.	One unit for each multiple of 10,000 square feet of ground space.
Public Open.	One unit for each multiple of 10,000 square feet of ground space. ( <u>Public ownership</u> ).

For a comparison of the changes to the previous version by White, et al, see the original version in appendix B. The basis for the revisions in the White method are explained below: **RESIDENTIAL.** The method for classifying residential use has been partially modified for the purpose of this report. White's method of distinguishing the category of residential use was determined by the number of families per unit, i.e. , 1-2 families = "A", >2 - <7 families = "B", etc., and this has been preserved in this present report. White's formula quantified

residential structures strictly as one unit per number of families without regard to land surface area occupied (i.e., a single-family home and a large apartment building with more than six families, are both classified as "one unit"). However, the present quantitative tabulation now utilizes the "1 unit per 10,000 square feet" formula used for all structures.

Both methods fail to completely and accurately describe other aspects of the same structural unit, i.e., multi-storied buildings. In one sense, the most appropriate classification method would be to describe that element which takes place on the land's surface. In other situations, it seem more appropriate to indicate the dominant use of the structure.

The Riverplace site is an example of this type of unique situation where the ground floors were utilized as parking areas and commercial shops, but the two or more levels above these areas are entirely residential. Therefore, in this instance, it appeared more appropriate to tabulate the buildings according to their dominant use (Residential - C), but also include (within the text of the report), the ground level occupance type (the most likely category to become damaged in a flooding event).

OPEN SPACE (Trans./Ind., and Public). White's conversion factor for open space used multiples of 25,000 square feet. This formula created confusion when the classification alternated between buildings and open spaces. For the purpose of this report, the formula using 10,000 square feet is maintained. This should help to clarify similar alternating land uses in possible future studies.

There were several situations of open space that were difficult to differentiate as to their use category; whether they were industrial, or transport-related, or inactive. Few of the areas observed actually presented a distinct and identifiable use in any specific category. Therefore, both categories have been combined into a single "Trans./Ind.-open" category. Several of these areas show little or no structural development, or changes to the land. Many also appear to have unrestricted access, with evidence of extensive use by members of the public. Regardless of present function, these land parcels remain in private ownership and are not intended for public use, therefore they were not included in the next category, the classification which deals with publicly-owned land.

PUBLIC - OPEN. In White's report, there was no classification provision for open spaces such

as parks, recreation areas, and wildlife refuges. (This reflects pre-1957 changes in flood plain management rather than an oversight of White). There have been increases in this category since 1957, and there is a need for the additional classification of "Public" Open space in the tables. This category reflects all public-owned open space regardless of use. It also includes one exception which is further explained under the Oaks Amusement Park section.

## FINDINGS

### Burnside

This site extends from the northern edge present-day Banfield exchange complex, south to S.E. Stark street (Figs. 3,5). The east and west boundaries are S.E. Union Avenue and the Willamette River, respectively.

This site epitomizes the emphasis of river-oriented industries, rail yards, freight houses, and shops described in White's report; it also illustrates the relationship of these elements to the areas which are inundated by the flood of record (Figs. 3, 5).

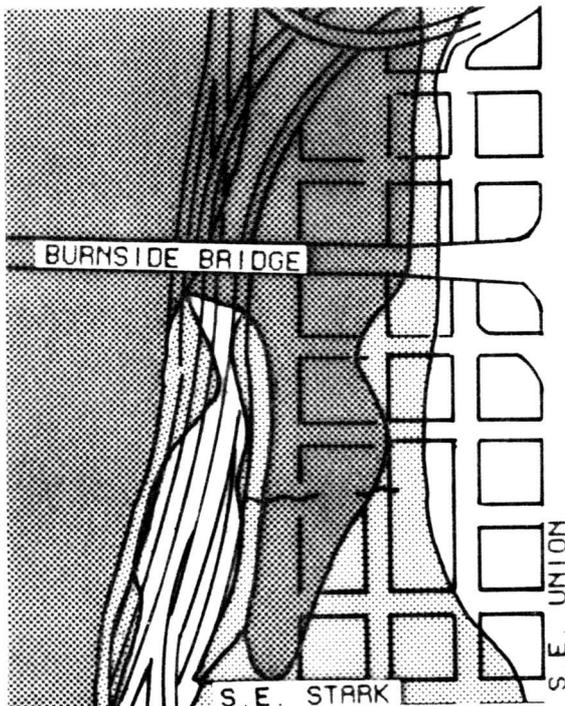
Some of the obvious changes which have occurred to these elements since 1957 can be seen in the comparison in photos 1-A and 1-B. (The comparison of 1957 to 1986 photos only illustrate the contrast between the extreme ends of the total period investigated; they do not indicate if changes occurred before, or after the regulatory period).

Along the western edge of the study area, there is a marked decrease in the number of "river-based" (i.e., making direct use of the riverine location in their processing and shipping activities) transportation structures which were removed to allow for construction of the highway complex (White, et al. 1958). Photo 1-B illustrates some of the major changes mentioned. (White may have been referring to a different site, because these changes are not apparent in the 1957 (1-A) photos of this site; they have apparently taken place since 1957).

Table 1.

BURNSIDE	1957 - 1972				1972 - 1986				1957 - 1986	
	STRUCTURAL UNITS				STRUCTURAL UNITS					
	OCCUPANCE CLASS	1957	1972	Net Change	Percent Change since 1957	1972	1986	Net Change	Percent change since 1972	Percent change since 1957
Residential - A										
Residential - C										
Commercial	27	26	-1	-4	26	27	1	4	0	
Industrial bldg.	6	6	0	0	6	6	0	0	0	
Transport bldg.	30	8	-22	-73	8	16	8	100	-47	
Trans./Ind. open	102	90	-12	-12	90	79	-11	-12	-23	
Public bldg.										
Public open										

The Burnside site is composed entirely of transportation, commercial, and industrial elements (Table 1), although there has been a reduction in the transportation units near the northern center portion of the site, and along the western edge (Fig. 5). Both of these areas involve large sections of the "A" zone (below the regulatory elevation).



Site No. 1	Site Name: <b>BURNSIDE</b>
500 - YEAR BOUNDARY →	ZONE B
100 - YEAR BOUNDARY →	ZONE A
100 - YEAR BOUNDARY →	ZONE B
500 - YEAR BOUNDARY →	ZONE B
Adapted from F.E.M.A. (F.I.R.M.) rev. 1982.	

Fig. 5

In the center area, most of the use appears to have alternated from the transportation structures existing in 1957, to open space in the 1972 photos, and finally, a slightly larger commercial warehouse structure appearing in the 1986 aerial photos. Similarly, the southern portion of this same strip has changed from an open space in the 1957 photos, to a medium-sized transportation structure in 1972, and a much larger combination commercial warehouse and office space structure prior to 1986.

The most dramatic change in this site is along the western edge adjacent to the river. Most of this fringe is classified as zone "A", although there is a small amount of zones "B", and "C", at the southern tip. This portion was heavily developed with structures related to the river transportation business as evidenced in the 1957 photos. During the pre-regulatory period, (1957 to 1972), this entire sub-area was cleared of buildings and replaced with nine lanes of highway development.

There has been very little apparent change in the eastern one-third of this study site. The reason apparently coincides with FEMA's designation of flood zones; the eastern portion is primarily in zones "B" and "C", above the 100-year elevation.

Field checks of the area reveal complete adoption of the waterproof type of flood proofing methods. These structural additions to guard against water intrusion into doors and windows, appear to be recently added to nearly all existing buildings (pre-1972), and integrated into the construction of the newer ones since 1972 (photo 2). There was no evidence of the flow-through type of floodproofing method. Flood water inundation alone, (depending upon the severity), would probably cause little if any damage to the majority of the development in this site. However, a modern-day flood of a magnitude similar to a 100-year event would interfere with traffic and transportation along this area, and create an unknown amount of structural damage to the highway system itself.

### River Place

The Riverplace site is bounded on the west and southwest by southwest Harbor Drive. The Marquam Bridge (added prior to 1972) completes the southern boundary and the Willamette River forms the east edge (Fig. 6).

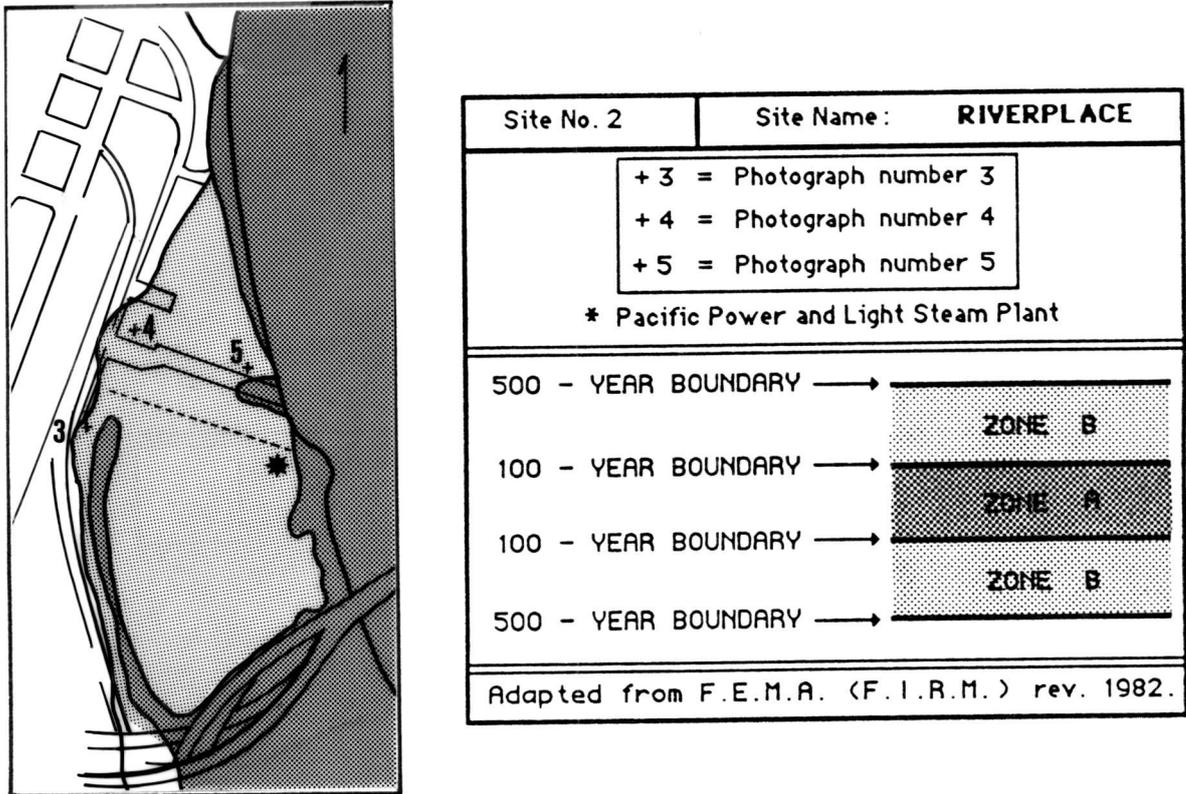


Fig. 6

The area immediately adjacent and to the south of the River place site includes the Pacific Power and Light Steam Plant. This plant formerly supplied steam heat and electricity to some of the downtown buildings. It was converted from sawdust fuel to natural gas in 1957, but has been out of operation since that time.

An imaginary line running east to west along the northern tip of the generating plant generally describes the southern edge of the Riverplace development proper. The area bounded by this same line and S.W. Montgomery Street to the north is now utilized as public parking for Riverplace visitors ( fig. 6 ).

Immediately south of the River Place parking lot is a large section of open space which has recently been cleared of debris and open industrial storage which still existed in the 1972 photo coverage. The area remains in private ownership at the time of this report, but is free

from structural development. It has been tabulated as "Trans./Ind.-open" although the only current use appears to be as access to the river for bank sportfishing. There are no barricades or restrictions to public access, but private ownership prevents its classification as "Public - open" use. Ideal future development of this area would be a public park, however, it is more likely to be used for additional office and/or residential development.

Table 2.

RIVERPLACE OCCUPANCE CLASS	1957 - 1972				1972 - 1986				1957 - 1986
	STRUCTURAL UNITS				STRUCTURAL UNITS				Percent change since 1957
	1957	1972	Net Change	Percent Change since 1957	1972	1986	Net Change	Percent change since 1972	
Residential - A									
Residential - C	0	0	0	0	0	10	10		
Commercial	6	6	0	0	6	3	-3	-50	-50
Industrial bldg.	10	10	0	0	10	0	-10	-100	-100
Transport bldg.									
Trans./Ind. open	306	306	0	0	306	212	-94	-30	-30
Public bldg.	11	11	0	0	11	11	0	0	0
Public open									

The most significant changes in the Riverplace study area took place during the period from 1972 until 1986. Air photo comparison illustrates the dramatic change from 1957 until 1986 (photo 1-A and 1-B). Riverplace remained relatively unchanged from 1957 until sometime after 1972. The Riverplace site demonstrated a complete transition from a lumber and metal-working industrial area in the first period, to a combination of commercial shops and condominium development in the second. Commercial office spaces are presently being constructed adjacent to these buildings.

In this site, flood hazard potential is reflected by the application of floodproofing and the non-residential use of ground floor areas. Some of these areas have been developed as "flow-through" off-street parking (photos 3 & 4), and other buildings along the esplanade are being utilized as commercial shops, stores, and restaurants (photo 5). The upper levels are used for residential purposes.

The use of a single structure for commercial store or vehicle parking on the ground floor with an office or residence above is not a new concept. However, the application in flood plains is the result of relatively recent floodplain regulations and will undoubtedly increase. This will intensify the need for a classification scheme which will identify the pertinent information; either the predominant use, or the ground level use. Riverplace is one of two developments within the context of this report which exhibits such a situation. (The other situation exists near Sellwood Bridge and will be described later ).

### Oaks Bottom

Oaks Bottom is a general local term used in reference to two subdivisions; one is Oaks Amusement Park and the other is Oaks Pioneer Park (see "A" and "B", fig. 7). Oaks Pioneer Park is now more frequently referred to as Oaks Bottom Wildlife Refuge. As their respective titles might suggest, both areas are two distinct land use types. The wildlife refuge (B), is the larger of the two, and is an undeveloped (structurally) wetland area presently maintained by the city of Portland for aquatic species habitat. A small two-acre portion of the southern tip of this area is privately owned (also undeveloped). This parcel has changed in terms of ownership from private to public, but otherwise has remained unchanged during the study periods represented (Willamette Greenway Update - Background Document 1986).

The commercial enterprise of Oaks Amusement Park (A), has also remained relatively unchanged except for the addition of several buildings and a property fenceline since 1972. It has catered specifically to the public use of its rides and picnic areas in the open spaces. A more accurate designation such as "Commercial-open" space does not exist. This unique distinction of Oaks Amusement Park presently warrants the only exception to the "public-owned" criteria for designation as "Public - open" space.

The City of Portland Bureau of Planning has designated this area as having "Rank I Historical Significance", lending it the significance of being "Individually the most important undesignated properties in the City, distinguished by their outstanding architectural, historical, or cultural values." This is the "Highest priority for landmark designation." (Willamette Greenway Update - Background Document 1986, 52).

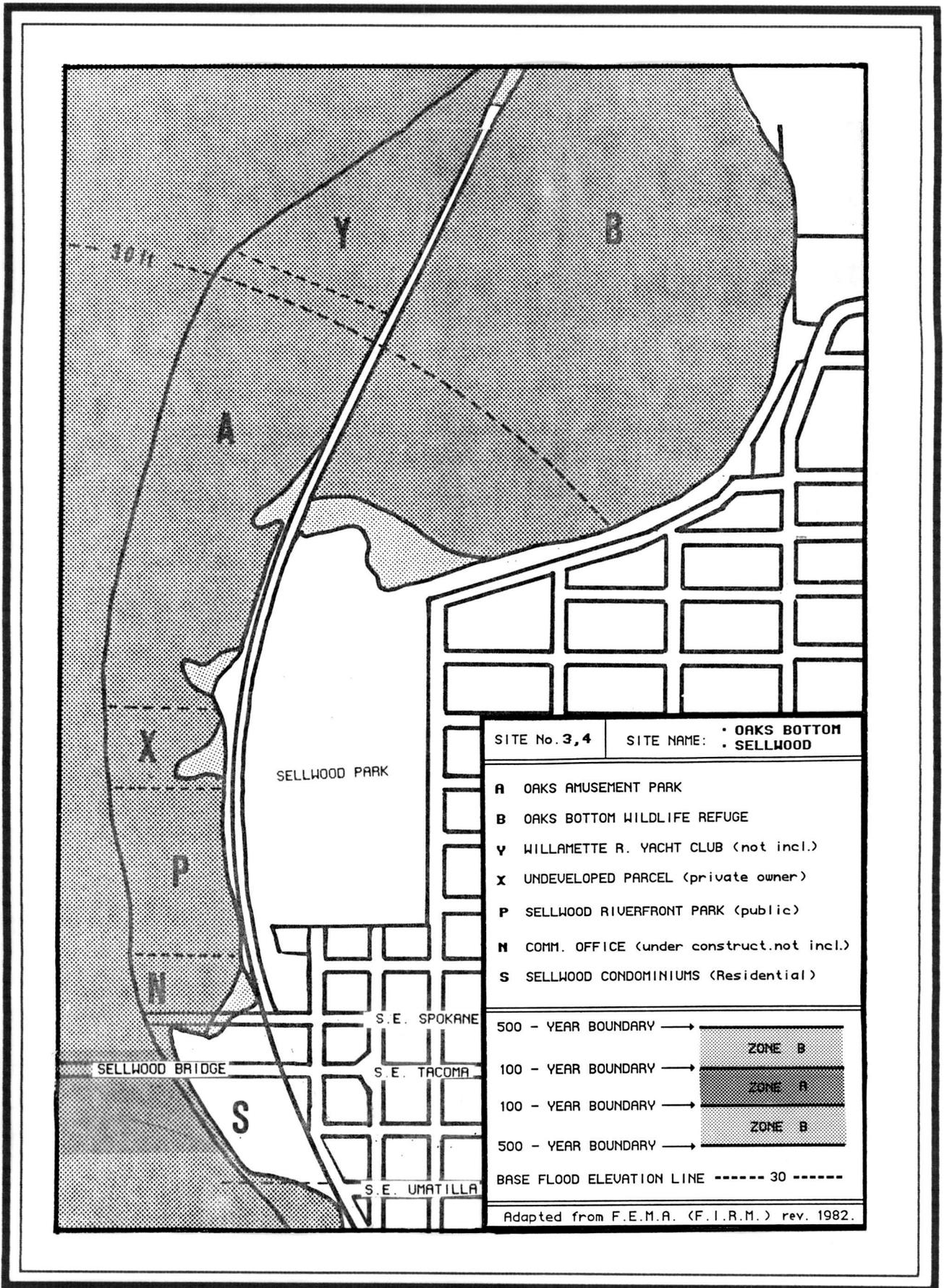


FIG. 7

Open space in this area (A), is used mainly for picnicking and similar outdoor activities. Some structures visible in the photos were examined in field checks and identified as covered picnic tables and gazebos. These types of structures were not tabulated.

Table 3.

OAKS BOTTOM OCCUPANCE CLASS	1957 - 1972				1972 - 1986				1957 - 1986
	STRUCTURAL UNITS				STRUCTURAL UNITS				
	1957	1972	Net Change	Percent Change since 1957	1972	1986	Net Change	Percent change since 1972	Percent change since 1957
Residential - A	1	1	0	0	1	1	0	0	0
Residential - C									
Commercial	10	9	-1	-10	9	9	0	0	-10
Industrial bldg.	0	0	0	0	0	3	3		
Transport bldg.									
Trans./Ind. open	5	5	0	0	5	5	0	0	0
Public bldg.									
Public open	134	133	-1	-1	133	130	-3	-2	-2

Virtually all of both sections of land in this area of the study are within the regulated flood zone "A" as described in the Flood Insurance Rate Maps (FIRM's). The one exception to this A-zone category, is characterized by the Railroad line of the Portland Traction Company which rests on an elevated land structure, placing it into the "B" zone (Fig. 7).

A 4.5 acre parcel ("X"), between Oaks Amusement Park and Sellwood Riverfront Park, and a 2.03 acre parcel (not shown) at the southern tip of the refuge have been in private ownership with no signs of structural development during both study periods. The City of Portland has recommended their purchase (by the city) as additions to the city's adjacent park, and refuge areas (Willamette Greenway Update - Recommendations to the Planning Commission 1987, 63).

### Sellwood

There are two other parcels immediately north of Sellwood Bridge ("P", "N". Fig. 7), which remained undeveloped (structurally) throughout the first investigation period, and well into the second. The northern parcel ("P"), has recently been purchased by the City of Portland, and has been developed into the *Sellwood Riverfront Park and Recreational Area*. The area designated as "N", remains in private ownership. At some time prior to 1972, it contained one structure which apparently served commercially as a small boat showroom with adjacent sales lot. Since 1972, the previous structure has been removed and the area has been inactive until very recently.

A large commercial office building is presently being constructed in this same area, although much closer to the water's edge. Much of it appears to be in the "B" zone and the western end appears to be in the "A" zone. It was required to utilize "flood-proof" structure methods (photos 6 & 7). It is not shown in the 1986 air photos, and has not been included in the tabulation. However, the previous, and other existing land uses are included Table 4.

Table 4.

SELLWOOD OCCUPANCE CLASS	1967 - 1972				1972 - 1986				1957 - 1986
	STRUCTURAL UNITS				STRUCTURAL UNITS				
	1967	1972	Net Change	Percent Change since 1957	1972	1986	Net Change	Percent change since 1972	Percent change since 1957
Residential - A									
Residential - C	0	0	0	0	0	7	7		
Commercial	12	7	-5	-42	7	5	-2	-29	-58
Industrial bldg.									
Transport bldg.									
Trans/Ind. open	58	62	4	7	62	24	-38	-61	-58
Public bldg.									
Public open	0	0	0	0	0	26	26		

The area in the immediate vicinity south of Sellwood Bridge ("S" in Fig. 7), has also undergone a dramatic metamorphosis. This site differs slightly from the others in its alternate use of some of the pre-existing structures. (A large warehouse remains outwardly

unchanged since the 1957, and 1972 coverage, but since that time, it has been converted into a large multi-storied restaurant). However, most of the other previous commercial storage structures have been removed and subsequently replaced by modern condominiums.

All of the structures (past and present) south of the Sellwood Bridge have been constructed above the 500-year flood elevation boundary ( FEMA zone "B". see Fig. 7). However, the new condominiums in this area have particular significance regarding flood plain land use in at least three ways; (1) they are newer; ( 2) they now physically occupy a larger portion of the land surface area, and; (3) the construction of some of these newer residences extends to a point much closer to the river's edge (zone "A"), than the previous use. In simple terms, there is a significant increase in structural property value; and some of that property may be more susceptible to an exceptional flood event. Photographs 8 and 9 give an indication of the proximity to the river's edge and the vertical distance. The pier-post construction method was required to meet the variance to local zoning restrictions (Muckleston 1987, personal communication).

#### SUMMARY

Data from the tables for the two periods indicates there has been no change in either the Residential - A, or the Public building categories.

Commercial and the Trans./Ind. categories both had decreases throughout both periods; the Tran./Ind. category dropped considerably more during the post-regulatory period.

There were increases in three categories. Residential - C, Public open, and Transport building, each either decreased, or remained constant during the pre-regulatory phase, but increased during the post- regulatory period. The increase in the Transport building category during the second period, took place only in the Burnside site, and did not appear to be consistent with the rest of the data.

Several other points regarding Portland's changing floodplain development may be summarized:

- \* Upstream storage, particularly on the Columbia River has contributed significantly to the reduction in the flood crest ( beginning prior to the 1956 flood - FEMA 1986,7).

- \* There has not been a severe flood event on the Willamette floodplains in Portland since 1964 (largely due to the upstream storage benefits).
- \* The water quality of the Willamette River has been improved since the first study period (pre-regulatory). The improvement has stimulated new interest in riverine development for residential, and some commercial uses such as restaurants and business offices.
- \* There is increased interest in recreational activity within the flood plains during the post-regulatory period (water-related, and outdoor activities near the river). It is difficult to tell if the shore activities have increased due to the improvement in water quality, or the opportunities created by the increased parks and recreational areas.
- \* Primarily since the post-regulatory period, the City of Portland is attempting to identify land parcels which would be proposed for inclusion into the Willamette Greenway, and those areas which should remain as industrial or residential. Privately owned property (along the floodplains), that are identified as unique and important natural resources are recommended for city purchase for use as wildlife habitat or park and recreation areas (Willamette Greenway Update 1985-86. Recommendations to the Planning Commission 1987, 9).
- \* There was no evidence of flood proofing methods used during the pre-regulatory period. They are commonplace in all of the study sites since 1972; they are a part of modern construction and retrofitted into the pre-existing structures (particularly in Banfield ).
- \* New construction in the "A" zone of the flood plain during the post-regulatory period is usually only as an extension of construction taking place in the "B" and "C" zones, i.e., Sellwood. (Banfield, and Oaks Amusement Park appear to be isolated exceptions to this observation). There have been significant increases in the "B" and "C" zones during the second period (River Place and Sellwood).
- \* Post-regulatory flood plain development is increasing in relative value per unit, and in its density immediately adjacent to the 100-year elevation.
- \* Generally speaking, the more labor-related transportation and industrial emphasis of the pre-regulatory period is being replaced by a more aesthetic and leisure-oriented environment consisting of recreation areas, condominiums, and modern office spaces which seek to provide a more scenic place of work for their employees.

## CONCLUSION

Legislation such as the N.F.I.P. of 1968, and the Flood Disaster Protection Act of 1973 have provided an awareness of regulatory boundary elevations and appear to have influenced some of the floodplain development decisions. Evidence to support this, appears in at least three major ways: (1) The increasing numbers of new flood-proof techniques being applied, both to new and to preexisting structures, and, (2) the adjacency relationship between the new developments and the 100 year flood elevation boundary (in some cases extending beyond previous structures before regulation), (3) there appears to be a shifts of floodplain land use.

The first evidence can be seen in the photos of buildings that have been constructed since floodplain regulations have been implemented. The flow-through type appear as the foundation of many new buildings, and the waterproofing type is most frequently used as a retrofit to buildings constructed prior to the pre-regulatory period.

The relative location of buildings to adjacent flood hazard zones is indicated by the presence or absence of floodproofing methods. The floodproofing methods serve as excellent indicators to identify those structures which are in the regulated zones of the flood plain; other structures located nearby but not within the regulated zones do not normally exhibit any floodproofing techniques.

The third piece of evidence is extrapolated from the data in the tables. It indicates a shift of land use away from Commercial, Transport, and Industrial classifications, and increases the shift toward larger residential-unit development, and Public open space (the increased use of public open areas would seem to be a lowered-risk use of the floodplains).

Flood plain regulation on development presently has more stringent requirements than at any time in the past, but it still may be far too lenient in its application and enforcement. This relaxed attitude is probably due to three major factors. (1) Most individuals have a tendency to forget about water unless there is either too much or too little of it. With this fear buried in their subconscious, there is, (2) a tendency (especially for developers) to measure elements of safety with an economic ruler; there is a willingness to gamble potential profits against a certain amount of damage or loss, especially to the new owner, and (3) the terminology "100-year event" seems to lull most laymen into the belief that such an event will not happen at any other time than "every one hundred years". If they think at all about the "one percent chance of occurring in any single year", this brings them back to the "calculated economic risk syndrome".

When White testified before the Senate subcommittee hearings in 1973, <sup>h</sup> He emphasized this very point. He stated, "in about 50 percent of the cases, the historic flood is less than the 100-year probability, and about 50 percent of the cases it is more. In some cases, the difference is drastic, and may be of great local significance." (Subcommittee Hearings, 1973, p.101).

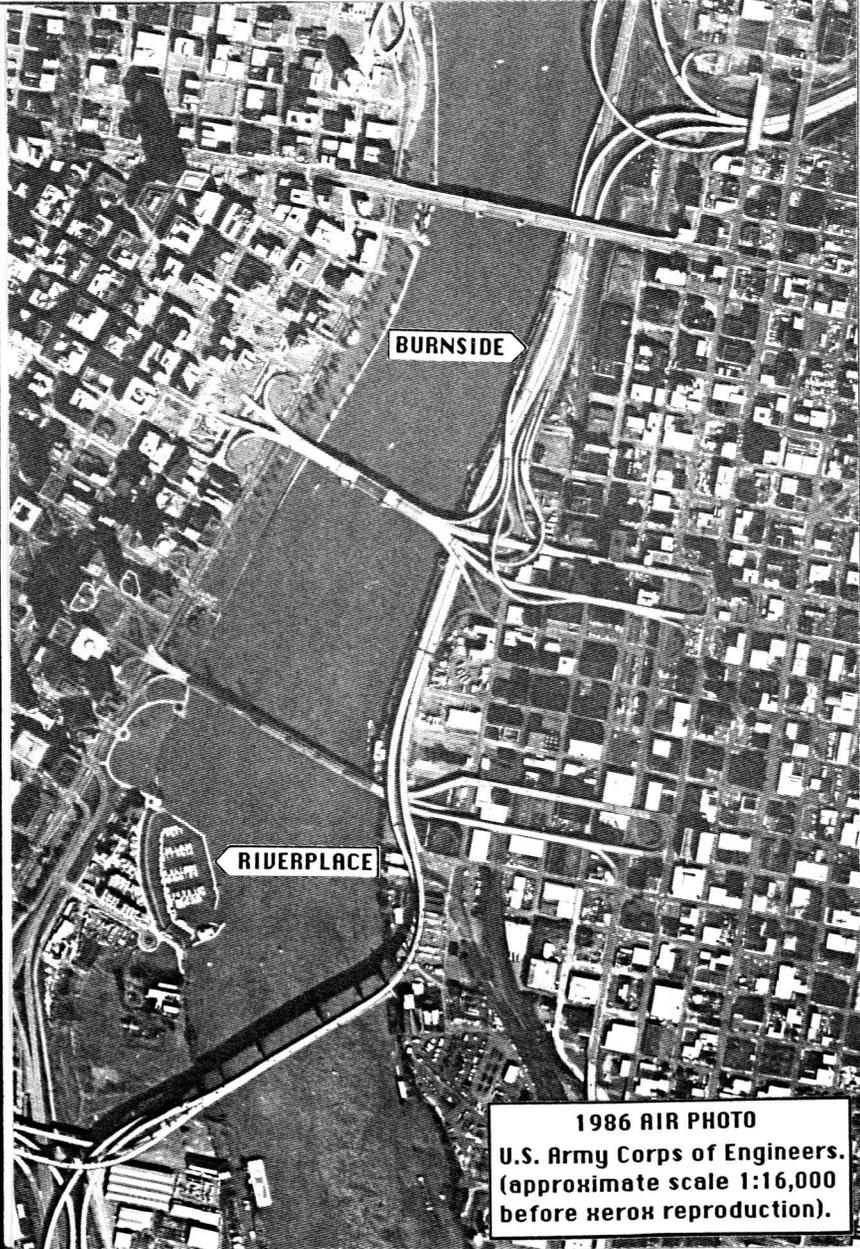
Floodplain regulations which discourage structural development below the 100-year elevation will do much to prevent flood damage up to that level. Ancillary developments tempt fate by crowding next to, and slightly above the regulatory level. They increase their chance of flood damages from a flooding event larger than the regulatory flood. Infrequent floods of greater magnitude may cause more damage than if the development were farther above higher flood elevations. The degree of damage sustained will depend primarily upon the extent of the flood above the 100-year level.

Increased protection and damage reduction would be obtained with higher elevational restrictions, including part of the "B" zone, for example, but this prospect is not likely to be readily acceptable by most communities at the present time.

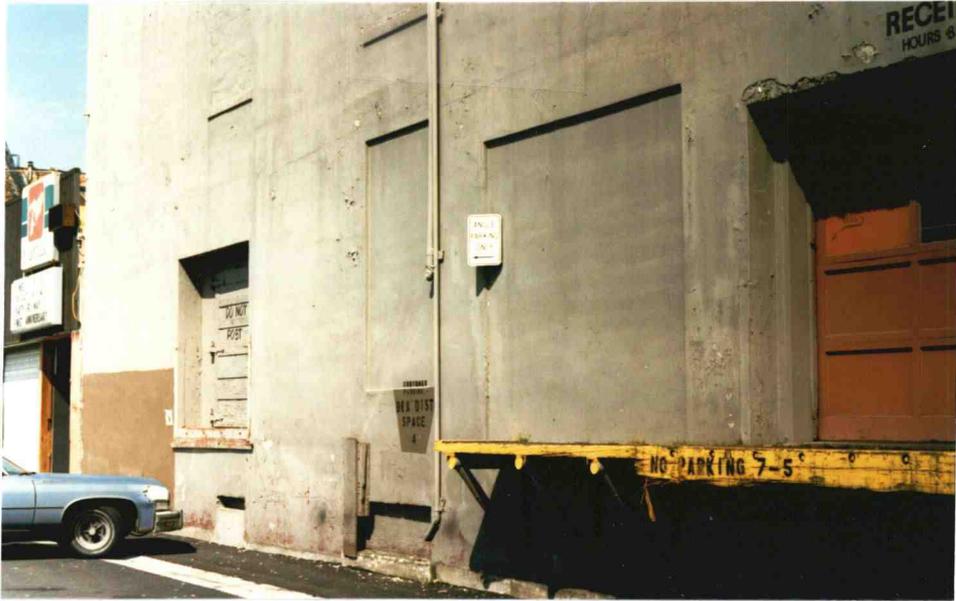
Based upon the evidence, it appears that the Portland floodplain occupation and development trends will continue very much the same as they have since 1972.



1957 AIR PHOTO  
U.S. Army Corps of Engineers.  
(approximate scale 1:17,000  
before xerox reproduction).



1986 AIR PHOTO  
U.S. Army Corps of Engineers.  
(approximate scale 1:16,000  
before xerox reproduction).



**Photo 2.**

Burnside. Facing east on second street. Virtually all of the buildings in this study area exhibited some form of flood proofing methods. The sealed openings and waterproof doors and closures in this photo were typical of the methods used in this area.



**Photo 3.**

Looking south toward southern extent of Riverplace development. Open "flow-through" flood proofing methods such as these were common, and were generally used for vehicle parking.



**Photo 4.**

Riverplace. Facing northeast. The most recent development. Commercial office spaces with covered parking in the flow-through open ground floor.



**Photo 5.**

Riverplace facing northwest. The condominiums along the esplanade utilize ground level space for shops, stores and restaurants; upper levels are condominiums. Note the "rip-rapping" bank stabilization, and boat marina in the lower right corner.



**Photo 6.**

View looking north from Sellwood Bridge. This new commercial office building has been started since the 1986 air photos. Note the proximity and river view advantage. Light-colored ground level on the left end illustrates the ground grade change down to zone "A" from zone "B" (on the right).

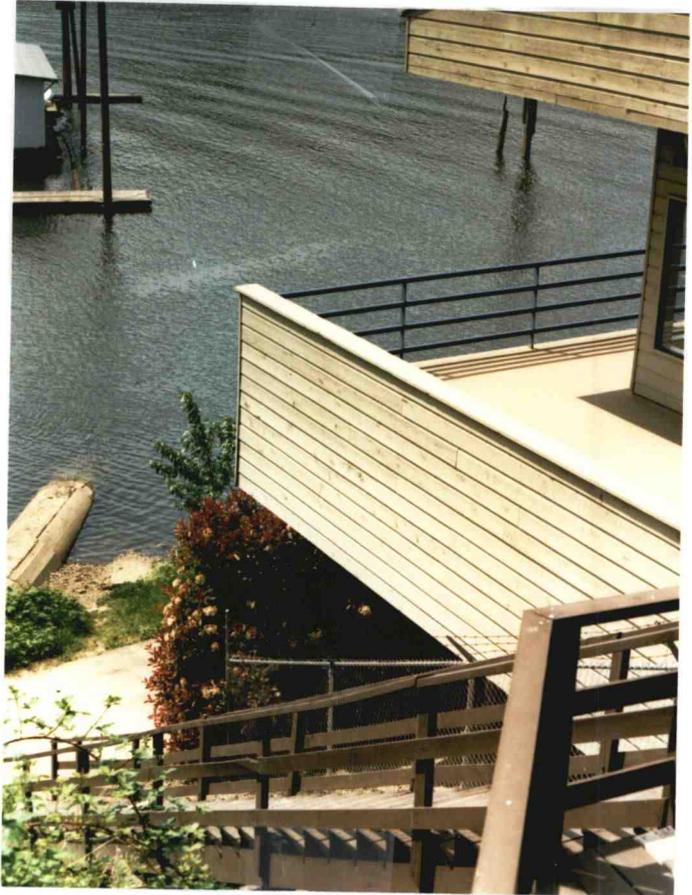


**Photo 7.**

A close-up view of the lower left corner of the above photo facing slightly more to the west. Taken one month earlier. This end of the building extends into the 100-year ("A") zone, evidenced by the flow-through floodproofing of the ground floor. The lowest habitable floor is 2" above the 100-year flood level (the point where the brick facing begins).

**Photo 8.**

A view of the corner veranda of one of the new condominiums immediately south of the Sellwood bridge. The view is facing due west, directly towards the river. Note the river's proximity.

**Photo 9.** (Bottom of page).

The area directly under the veranda is left open with piling supports. Fencing and evergreen hedge will eventually screen the understructure. Variances were necessary to construct these condominiums in this location.



REFERENCES

- U.S. Department of the Army, Office of the Chief of Engineers. 1976. *A Perspective on Flood Plain Regulations For Flood Plain Management*. Washington: G.P.O.
- \_\_\_\_\_. 1971. Flood plain management for Oregon cities and counties. *Bureau of Governmental Research and Service, and the Oregon State Water Resources Board*.
- Burton, I. 1961. Education in the human use of flood plains. Reprinted from *The Journal of Geography*, Vol. LX, No. 8, November. pp. 362-371.
- \_\_\_\_\_. 1958. Conclusions of the Conference on Flood Plain Regulation and Flood Insurance. *Paper presented to the Council of State Governments by the General Assembly of the States, meeting in Chicago, Illinois. December 4-5*. Disseminated by P.L. Ingraham, Director of Research.
- Dunham, A. 1959. Flood control via the police power. In *University of Pennsylvania Law Review*, vol. 107, No. 8 : 1098-1132.
- The Federal Emergency Management Agency, Interagency Task Force on Floodplain Management. 1986. In *A Unified National Program for Floodplain Management*. Washington: G.P.O.
- The Federal Emergency Management Agency. *Flood Insurance Study City of Portland, Oregon*. rev. Jan. 1986. Washington: G.P.O.
- \_\_\_\_\_. 1982 (a). *Flood Insurance Rate Map*. Community panel No. 4101830035C. Scale 1" = 800'. Revised October 19, 1982. Federal Emergency Management Agency.
- \_\_\_\_\_. 1982 (b). *Flood Insurance Rate Map*. Community panel No. 4101830045C. Scale 1" = 800'. Revised October 19, 1982. Federal Emergency Management Agency.
- Gleeson, George W. 1972. The return of the river: The Willamette River, Oregon. *Water Resources Research Institute*. June. Oregon State University. Corvallis, Oregon.
- Greenburg, E., Leven, C.E., and Schlottmann A. 1974. Analysis of Theories and Methods for estimating benefits of protecting urban floodplains. *A report to the U.S. Army Institute for Water Resources by the institute for Urban and Regional Studies Washington University, St. Louis, Mo.*

- Hogan, T.H. 1963. *State Flood-Plain Zoning*. An article reprinted for private circulation from *DePaul Law Review*, vol. XII, No. 2, Spring-Summer.
- Kates, R.W. 1962. *Hazard and Choice Perception in Flood Plain Management*. Chicago: University of Chicago Press.
- Kusler, J.A. 1982. Floodplain Regulations and The Courts 1970-1981. Special publication No. 5, Report prepared for the U.S. Water Resources Council and the Tennessee Valley Authority as one chapter of *Regulation of Flood Hazard Areas to Reduce Flood Losses*, vol. 3. Natural Hazards Research and Applications Information Center.
- Kusler, J.A. 1985. Roles along the rivers. Regional programs meet national policy. *Environment* 27: 18-20,37-44.
- Muckleston, K.W. 1976. The evolution of approaches to flood damage reduction. *The Journal of Soil and Water Conservation*. 76: 53-59.
- Muckleston, K.W. 1983. The impact of floodplain regulations on residential land values in Oregon. *Water Resources Bulletin*. Paper no. 82074. vol. 19. no. 1. February. American Water Resources Association.
- Muckleston, K.W. 1987. Personal conversation with Dr. Muckleston. Accounting of his conversation with Portland Planning department in reference to the variance granted for the construction of the condominiums and commercial building in vicinity of east side of Sellwood bridge .
- Murphy, F.C. 1957. *Regulating Flood-plain Development*. Chicago: University of Chicago Press.
- Perrey, J.I. 1955. Application of zoning principles and laws to flood plain regulation. *Paper presented to Hydraulics Division, ASCE, New York City, New York*.
- Portland Bureau of Planning. 1986. Background document. *The Willamette Greenway Update - 1985/86*. Portland: Bureau of Planning.
- Portland Bureau of Planning. 1987. Recommendations to the Planning Commission. *The Willamette Greenway Update - 1985/86*. Portland: Bureau of Planning.
- \_\_\_\_\_. Statements of Gilbert White, Jon A. Kusler, and James M. Wright during the *Hearings before the Subcommittee on Housing and Urban Affairs of the Committee on*

*Banking, Housing and Urban Affairs United States Senate. Ninety-third Congress, first session on S. 1495 and H.R. 8449 Flood Disaster Protection Act of 1973. October 31, 1973. Washington: G.P.O.*

Sheaffer, J.R. 1962. *Flood Proofing: An Element in a Flood Damage Reduction Program. Chicago: University of Chicago Press.*

Shaeffer, J.R. 1964. Economic feasibility and use of flood maps. *Paper presented to Northeastern Illinois Metropolitan Area Planning Commission, before the Highway Research Board Conference, Washington, D.C.*

Shaeffer, J.R. 1967. *Introduction to Flood Proofing. Chicago: Center for Urban Studies The University of Chicago.*

Sutton, W.G. 1963. Planning for optimum economic use of flood plains. *Paper presented at Environmental Engineering Conference, American Society of Civil Engineers, Atlanta, Georgia, February 25-28, 1963.*

\_\_\_\_\_. 1983. *Volume II Manual of Remote Sensing. 2nd ed. American Society of Photogrammetry. Falls Church, Va.: The Sheridan Press. pp.1543-1556.*

\_\_\_\_\_. 1961. *Papers on Flood Problems., ed. G.F. White. Chicago: University of Chicago Press.*

— WHITE, G.F., et al. 1958. *CHANGES IN URBAN OCCUPANCE OF THE FLOODPLAINS IN THE UNITED STATES*  
Dept. of Geography research paper. No. 57. University of Chicago.

White, G.F. , and Cook, H.L. 1962. Making wise use of flood plains. In *Natural Resources, Energy, Water, and River Basin Development*, vol. I. United States papers prepared for the United Nations Conference on th application of Science and Technology for the benefit of the less developed areas. pp. 1-31. Washington, D.C.: U.S. G.P.O.

\_\_\_\_\_. 1972. *Flood Hazard Evaluation Guidelines for Federal Executive Agencies. United States Water Resources Council. Washington, D.C.: Water Resources Council.*

U.S.G.S. 1961. Lake Oswego, Oregon quadrangle. 7.5 minute series topographic map. Scale 1: 24,000. Edited and photorevised 1984 from aerial photographs taken 1981 and other sources. DMA 1474 I NW - Series V892. Published by U.S.G.S.

U.S.G.S. 1961. Portland, Oreg. - Washington quadrangle. 7.5 minute series topographic map. 1: 24,000. Edited, and photorevised 1977 from aerial photographs taken 1970 and 1975. AMS 1475 II S.W. - Series V892. U.S.G.S.

U.S.G.S. 1975. Portland, Oregon-Washington quadrangle. 7.5 minute series  
(orthophotoquad).

1: 24,000. AMS 1475 II S.W. - Series V092. U.S.G.S.

## GLOSSARY

(adapted primarily from Oregon's Flood Plains, State Water Resources Board 1972)

### Ancillary Area

That area outside of the area where flood plain regulations are adopted and enforced which may still be susceptible to damages from a very large flood; e.g., between the intermediate regional flood and standard project flood limits. Items having a very high economic, historical or social value should not be located in this area unless adequately flood proofed; also referred to as a warning zone.

### Flood Crest

The greatest depth or elevation reached by a specific flood or expected during a predicted flood of specific magnitude. Sometimes referred to as maximum stage.

### Flood Control

The process of keeping the floodwaters away from selected areas utilizing a wide range of structures such as dams and reservoirs, dikes and levees, revetments and channel works, and various drainage facilities. These are commonly referred to as flood control projects, flood control structures, flood control works or flood control measures. The concept is referred to as structural flood control.

### Flood Damages

Those costs, usually economic, which can be attributed to floods. They might include such items as damage to structures, utilities and roads; damages from soil erosion; or crop damage. Sometimes referred to as flood losses.

### Flood Disaster Relief

A wide variety of assistance made available to private citizens and governmental bodies to replace, repair or restore flood damaged facilities, structures, or lands.

### Flood Extent

The area that has been inundated by a specific flood or which can be expected to be inundated by a predicted flood of specific magnitude, usually expressed in acres. The extent of flooding will vary as the flood progresses.

### Flood Frequency

The frequency with which a flood of a given discharge has the probability of recurring. Calculations are based upon historical records.

### Flood Plain.

The area adjoining a stream, tidal estuary, or coast that is subject to inundation by a regional flood.

### Flood Plain Delineation

The process of showing in a graphical form, usually on a map or photo mosaic, areas which have been inundated by a specific flood or which can be expected to be inundated by a predicted flood of specific magnitude.

### Flood Plain Regulations

Legal tools by which flood plain use and development can be regulated, including land use zoning, building codes provisions, subdivision regulation provisions, health code provisions, and exercise of other regulatory authorities with respect to flood prone areas.

### Flood Proofing

Any combination of structural and nonstructural additions, changes, or adjustments to properties and structures primarily for the reduction or elimination of flood damage potential to lands, water and sanitary facilities, structures and contents of buildings.

### Floodway

The normal stream channel and that adjoining area of the natural flood plain needed to convey the waters of a regional flood while causing less than one foot increase in upstream flood elevations.

### Floodway fringe.

The area of the flood plain lying outside of the floodway. (See regulatory flood fringe).

### One-hundred year flood

A flood occurring on the average of once in 100 years and having a one percent chance of occurring in any single year. It is based on a statistical analysis of available streamflow records or analysis of rainfall and runoff characteristics in the general region of the watershed.

### Regulatory Flood

A flood of a specific magnitude which has been adopted as the basis for regulatory activities, design of flood protection works, or other flood plain activities. It is selected by evaluating the flood potential, flood characteristics, flood frequencies, stream hydrology and other considerations. It is sometimes referred to as the design flood, selected Flood, and designated flood.

Regulatory Flood Fringe. (see floodway fringe).

The portion of the regulatory flood plain beyond the limits of the regulatory floodway. It is subject to less frequent and lower velocity flooding and does not play a major role in passing flood flows.

Regulatory Flood Level.

The height of the regulatory flood discharge measured at points along the watercourse.

Regulatory Flood plain.

The area adjoining a river, stream, lake or ocean which is inundated by a regulatory flood. For a riverine area, this usually consists of a regulatory floodway and regulatory flood fringe.

Standard Project Flood

A flood that will result from the occurrence of the most severe combination of meteorological and hydrological conditions considered reasonably characteristic of the geographical area in which the drainage basin is located, *excluding extremely rare combinations*. The peak discharge for a standard project flood is generally 40 to 60 percent of the probable maximum flood for the same location. Sometimes referred to as the maximum probable flood.

(Data tabulation method used by Gilbert White, et al. *Changes in Urban Occupance of Flood Plains in the United States*. 1958. p. 53-54).

"The definitions employed in measuring structural units are as follows:

Residential uses

- A. One unit = one single-family or double-family dwelling regardless of floor space or number of stories. Rowhouses count one unit for each house.
- B. One unit = one apartment buiolding with more than twofamilies and less than seven families.
- C. One unit = one apartment building with more than \*six families.

No garages or other outbuildings are counted.

Commercial uses

One unit = each separate store, office or warehouse building in multiples of 10,000 square feet of ground space. Small buildings auxiliary to main buildings are not counted. If a building is less than 10,000 square feet and is used for a separate purpose it counts as one unit.

One unit = a group of two or more storage tanks or storage tanks or storage bins above ground associated with a commercial enterprise.

Industrial uses

One unit = each separate building used for industrial purposes in multiples of 10,000 square feet of ground space. Small buildings auxiliary to main buildings are not counted.

One unit = each 25,000 square feet of open space used for processing and transportation uses associated with industry. This includes storage yards and plant switching facilities.

Transportation uses

One unit = each separate building or bridge used for transportation purposes in multiples of 10,000 square feet of ground space.

One unit = each 25,000 square feet of open space used for transportation purposes. This includes railroad switching and classification yards, truck parking yards, air fields, and open storage yards at rail and water terminals.

Public uses

One unit = each building used for public purposes or for public utilities in multiples of 10,000 square feet of ground space. This includes pumping plants, transformer stations, and waste disposal plants. Small auxiliary buildings are not counted."

\* White later lists this number as "seven" (White 1958, p. 169).