Assessing Permit Compliance in Residential Areas Using Color 35-mm Aerial Photography*

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ABSTRACT: The majority of communities in the U.S. have implemented programs to control development within their jurisdictions. Often, such programs are linked to land use and subdivision control regulation designed to regulate both the use of land and many aspects of structures to be built. Notification of intent to build is required by most communities. Often, a permit is required for both new structures and structural additions. Because new residential structures are viewed easily from streets, most are registered on tax rolls. However, structural improvements often are located behind existing residential units and are, therefore, difficult to view.

This paper will describe the use of aerial low oblique color 35-mm photography to identify structural improvements to residential units in Green Bay, Wisconsin. Results were compared to permit records to establish rates of compliance and to generate estimates of tax revenues lost.

INTRODUCTION

RECENT U.S. Bureau of Census estimates suggest that 80 percent of all tax revenue collected by local governments is derived from property taxes. Of these property taxes, it has been estimated that over 50 percent is derived from residential property. For communities that rely so heavily on property taxes to finance government and public services, it is essential that they maintain efficient, effective programs of property assessment and reassessment.

In many communities, control of identification of taxable property is provided by historical records of existing property and by issuance of building permits for new structures. Without a building permit, many structures and improvements cannot be built legally. Because new large structures, such as homes and commercial units, are easily observed, compliance with permit requirements is very high.

Permit compliance for new structural improvements to existing properties appears to be problematic. Structural improvements tend to be small room additions, decks, pools, and outbuildings, and often are located at the rear of original structures. As a result, structural improvements often are not observed easily from streets.

Without the issuance of permits for structural improvements, identification of those improvements is difficult and dependent upon a program of property reassessment. Because comprehensive reassessment is so expensive, few cities engage in these activities. For example, the City of Green Bay, Wisconsin spent about $800,000 in 1978 for such an assessment.

THE STUDY

Beyond complete reassessment of private property, many communities require that a permit(s) be issued for certain types of structural improvements. Knowledge of proposed structural improvements allows communities to schedule inspections to maintain standards and compliance with appropriate zoning/subdivision regulations. Additionally, the issuance of building permits often leads to increased revenues from permit fees, property assessment, and reassessment.

While the Green Bay permit program is representative of programs around the country, such programs often are neither effective nor efficient. To test the hypothesis that permit compliance for structural additions is marginal in residential areas of Green Bay, five sample areas were selected for analysis. Study objectives were (1) to develop methodology to assess permit compliance using 35-mm aerial photography; (2) to assess the utility of these aerial photographic techniques to analyze structural improvements in urban residential areas; (3) to identify rates of permit compliance for each category of improvement within study areas; (4) to estimate tax revenues lost due to permit noncompliance; and (5) to estimate project cost-effectiveness.

DESCRIPTION OF STUDY AREAS

Five areas of study were selected for analysis of residential land with in the City of Green Bay. Land use within the City of Green Bay can be categorized as follows: residential, 20.7 percent; commercial, 3.2 percent; public/institutional, 10.2 percent; industrial, 8.3 percent; agricultural, 41.0 percent; roads/streets, 14.1 percent; and other, 2.5 percent. Total residential area covers about 2417 ha (5973 ac) (source – Green Bay Planning Department). The five study plots selected represent approximately 3.67 percent of total residential land within Green Bay.

RESEARCH METHODS

To establish permit compliance, comparison between historical records and current 35-mm oblique slides was required. Historical records used were 1971 Wisconsin Department of Transportation (WDOT) air photos and original building plans. In the spring of 1986, five residential areas were flown for aerial photographic coverage to test the value of hand-held oblique 35-mm color slides to aid in the identification of residential structural improvements.

Small format aerial photography has been applied to a wide range of problems. Woodcock (1976) has presented a thorough discussion of equipment and procedures when utilizing small format cameras for aerial reconnaissance. Most applications of small format aerial photography have been to natural resource problems, particularly forestry application. Paine and McCadden (1988) successfully applied 70-mm large-scale aerial photography to forest inventory practices. Hagen and Smith

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(1986) predicted tree groundline diameters using crown measurements made on 35-mm photographs. Heer and Smith (1986) were able to estimate density of young pine plantations using vertical 35-mm aerial photographs while McCarthy *et al.* (1982) assessed spruce-fir forest characteristics in an attempt to predict stand hazard and potential losses to spruce budworm. Tueller *et al.* (1988) used helicopter-borne 35-mm aerial photography to measure changes in rangeland vegetation.

A variety of urban-based problems have been assessed with aid from conventional vertical aerial photography. Attempts to estimate urban area population have been made with varying degrees of success (Morrow-Jones and Watkins, 1984; Lo, 1986). Assessing urban area change, transportation plan alternatives, and urban housing characteristics with aerial photography are presented by Avery and Berlin (1985) and Ford (1979). Contemporary issues regarding urban landfills and hazardous waste dumps have been evaluated using large to medium scale aerial photography and other remote sensors – Landsat, hand-held infrared scanner (Stohr *et al.*, 1985; Lyon, 1987).

While urban applications of aerial photography are many, attempts made to assess compliance with land use/building permit programs and impacts to tax revenues have not been made, or have not been published widely. Blazquez *et al.* (1988) report that appraisel of citrus groves for tax purposes was successful using color infrared aerial photography and duel color video.

The use of oblique photographs and oblique 35-mm aerial photography is documented well and is not within the scope of this paper (Eastman-Kodak, 1974; Fleming and Dixon, 1981; Niedzwiedz, 1986; Roberts and Griswold, 1986; Shafer and Degler, 1986). Recent efforts to produce controlled results from oblique 35-mm photos are reported by Evans and Mata (1984).

Equipment for this study consisted of two 35-mm SLR cameras equipped with 50-mm lenses, No. 1A skylight filters, and auto-advance motor drives. These compact, lightweight cameras facilitated operation and viewing during the mission. Film employed was standard Kodak Ektachrome and Kodachrome (ASA 64).

There were several aircraft requirements including an aircraft large enough to accommodate the photo team consisting of a photographer, spotter, and pilot. The aircraft must have a moveable window for the photographer (preferably hinged at the top). Aircraft wings should be attached at the top of the aircraft to allow an unobstructed view of areas to be photographed. For this project, a Cessna 172 high-wing aircraft was used and has been found suitable in other studies (Niedzwiedz, 1986).

Because this was a pilot effort, small sample areas were flown and little flight planning was required. Flight lines were established parallel to, and approximately 92 metres (300 feet) from, selected streets within the study areas. Flying altitude was 274 metres (900 feet), the FAA established minimum altitude for the Green Bay metropolitan area. As the aircraft traveled along flight lines, oblique slides were taken in sequence from the open window. An oblique angle of approximately 45 degrees and slide converage endlap and sidelap of about 30 percent were maintained.

To identify improvements within selected study plots, current 35-mm slides were interpreted to identify structural improvements. These include outbuilding-storage, patio/deck, room additions, swimming pools-in and above-ground, and new structures-detached from the residence (Figure 1). Improvements were annotated on Green Bay lot ownership maps (Figure 2). All lots identified as having one or more improvements requiring a permit were checked against records to establish structural content of original building blueprints. If aerial interpretation results were verified (located) on original blueprints, improvements were judged as in compliance. If verification was

FIG. 1. Aerial oblique of the residential study area shown in Figure 2. Perimeter of oblique coverage is shown by dashed line in Figure 2. Photograph was made from an oblique color slide.

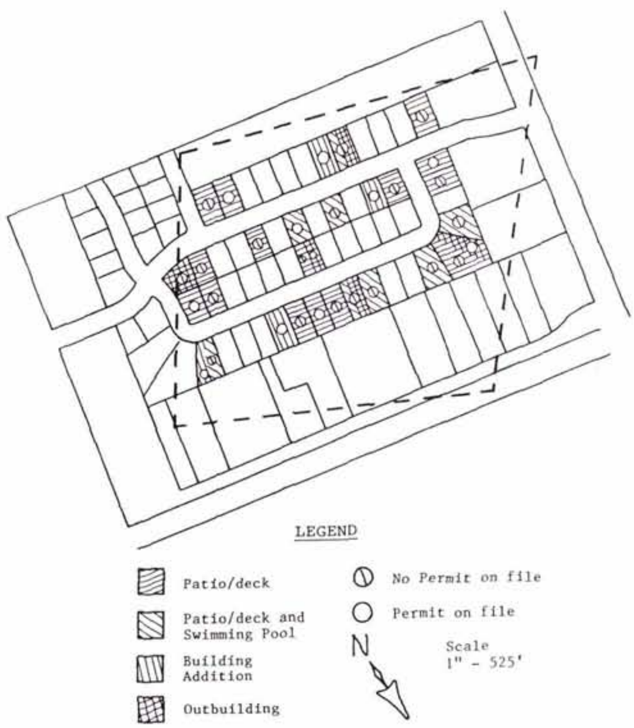

FIG. 2. Map of residential lots with structural improvements. Type of structural improvement and permit compliance are indicated as per legend. Dashed lines denote extent of oblique photo coverage of Figure 1. Original lot ownership maps consisted of base map and transparent overlays.

not made on blueprints, lot files were checked for record of permit(s). Any improvement showing a record of permit was judged to be in compliance.

A review of lot files showed that not all had original blueprints on record. To address this problem, historical stereo color aerial photos taken in 1971 (scale: 1 inch = 475 feet (1:5,700) – Wisconsin Department of Transportation) were interpreted and compared to interpreted 1986 color slides. For those lots having evidence of structural improvements since 1971, files were checked for record of permit(s) and determination was made of

TABLE 1. RESIDENTIAL STRUCTURAL IMPROVEMENTS AND PERMIT COMPLIANCE. UNITS PER IMPROVEMENT TYPE WERE IDENTIFIED USING COLOR SLIDES. PERMITS ISSUED PER IMPROVEMENT TYPE WERE IDENTIFIED BY STUDYING LOT OWNERSHIP FILES.

Improvement Type	Units Identified	Permits Issued	Units Without Permit	Percent Compliance
Outbuilding (Storage)	95	23	72	24.2
Patio/deck	161	33	128	20.5
Room addition	36	25	11	69.4
Swimming pool (In- and above-ground)	36	16	20	44.4
New Structure (detached)	3	1	2	33.3
Totals	331 (on 256 residential lots)	98	233	29.6

compliance or noncompliance. For those lots with improvements before 1971, no further analysis was conducted.

Results of the analysis were mapped and tabulated (Table 1). All aerial slide interpretation was assessed against "groundtruth" by field inspecting each lot by auto or by foot. Interpretive accuracy for all study areas averaged 91 percent correct classification.

Interpretive accuracy was established by comparing results of slide interpretation with field tallies of structural improvements identified per lot parcel.

RESULTS AND DISCUSSION

Interpretive analysis of slides and historical records indicated that since 1971, 256 lots of 1100 lots studied had at least one (1) structural improvement requiring a permit. Official city records show that a total of 331 permits should have been on file for improvements identified by means of aerial interpretation. A total of 98 permits were issued for improvements, which yielded an overall compliance rate of 29.6 percent. Percent compliance for specific structural improvements were as follows: outbuilding, 24.2 percent; patio/deck, 20.5 percent; room addition, 69.4 percent; swimming pool, 44.4 percent; and new structure-detached, 33.3 percent (Table 1).

Results of this research showed that 35-mm oblique color slides and additional data sources can be utilized to identify residential development and check permit compliance. The approach is straight-forward, and in this study was relatively inexpensive, efficient, and effective. Field work established interpretative accuracy at 91 percent.

Experience suggests that interpretation accuracy and efficiency could be improved by aligning flight lines perpendicular to streets and by increasing oblique angle to 65 degrees. These changes should increase the visibility of structural improvements by reducing the "masking" or hiding of structural improvements behind original residential structures.

Project costs related to photography include photo equipment, film and film developing, and aircraft rental. Assuming that most public agencies have access to necessary photographic equipment, costs related to photography should be less than $200 per 1100 residential units. Project time devoted to slide/photo interpretation ranged from 50 to 70 residential units per hour, or 400 to 560 units per day, depending upon characteristics of the residential neighborhood under study (Table 2).

Time devoted to traditional study of lot ownership files is considerably more than that associated with slide/photo interpretation. In this study, approximately 43 hours were spent studying 256 ownership files. Those files without building blueprints required photo interpretation of 1971 WDOT color aerial photos for evidence of structural improvement. Interpretation time (per unit) devoted to this task approximates that associate with slide interpretation (i.e, 50 to 70 residential units per hour).

Single and duplex family residential units are most likely to have structural improvements of the type studied. Extrapolation of study results suggests that the approximately 30,000 single and duplex units in the City of Green Bay could be analyzed using these methods for about $25,000 (Table 2). Using conservative estimates of the average values associated with each type of structural improvement, the estimated value for all noncompliance improvements identified within study areas is $522,000 (Table 3). When this figure was extrapolated to all Green Bay residential land of single or duplex type, it is estimated that $14,236,000 worth of residential property is not being taxed per year. Taken together, projected project cost and property value not taxed indicate that every project dollar expended will yield approximately $570 of taxable property. Applying tax

TABLE 2. PROJECT TASKS AND HOURS PER TASK ARE PRESENTED. WHERE APPROPRIATE, TASK UNITS COMPLETED PER HOUR ARE GIVEN ALONG WITH ESTIMATES OF TOTAL COSTS PER TASK. COSTS ASSOCIATED WITH THE SAMPLE STUDY AREAS ARE EXTRAPOLATED TO ALL GREEN BAY RESIDENTIAL AREAS.

Project Task	Task Hours-Actual	Units Completed/Task/Hr.	Estimated Project Costs*	Costs Extrapolated to All Green Bay Residential Units (30,000)
Aerial photography-oblique slides five (5) residential sites-1100 units	2 hours	NA	$200 (actual)	$ 5,454
Color oblique slide interpretation and map notation — 1100 residential lots	19 hours	50-70 residential lots	$157 @ $8.25/hr.	4,281
Analysis and map notation of lot ownership files — 256 lots with improvements	43 hours	6 files	$355 @ $8.25/hr.	9,681
Color vertical aerial photo interpretation (of 79 lots without design blueprints)	25 hours	50-70 residential lots	$206 @ $8.25/hr.	572
			$918	$25,034

* The author and a student assistant completed the project. Actual aerial photo flight costs are shown.

TABLE 3. STRUCTURAL IMPROVEMENTS NOT IN COMPLIANCE WITH GREEN BAY'S PERMIT PROGRAM ARE ENUMERATED. MEAN VALUES ($) FOR EACH TYPE OF STRUCTURAL IMPROVEMENT ARE USED TO ESTIMATE TOTAL VALUE OF ALL STRUCTURAL IMPROVEMENTS NOT IN COMPLIANCE IN THE STUDY AREAS. BECAUSE THESE IMPROVEMENTS ARE NOT IN COMPLIANCE, THEIR ASSOCIATED VALUE IS NOT TAXED. STUDY AREA VALUES WERE EXTRAPOLATED TO OBTAIN AN ESTIMATE OF TOTAL GREEN BAY STRUCTURAL IMPROVEMENT VALUE NOT TAXED. USING THE GREEN BAY PROPERTY TAX RATE, AN ESTIMATE OF ANNUAL TAX REVENUES LOST WAS OBTAINED.

Type of Structural Improvement	Improvements Identified-No Permit	Estimated Mean Value of Each Improvement	Total Estimated Value of All Improvements in Study Area	Total Estimated Value of all Green Bay Residential Units (nearest 1000)*
Outbuilding (Storage)	72	$ 500	$ 36,000	$ 982,000
Patio/Deck	128	2,000	256,000	6,982,000
Room Addition	11	10,000	110,000	3,000,000
Swimming Pool (above or in-ground)	20	5,000	100,000	2,727,000
New Structure (detached)	2	10,000	200,000	545,000

Total Estimated Non-taxed Value ($) in Study Areas	$522,000
Total Estimated Non-taxed Value ($) All Green Bay Residential Units*	$14,236,000
Green Bay Tax Rate (Per $1,000 of assessed value)	$ 28.10
Annual Tax Revenues Lost	$ 400,087

* Study results extrapolated to 30,000 Green Bay residential units

rates utilized in Green Bay, $16.00 will be added annually to city coffers for every project dollar spent.

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