Capital Needs of the Public Housing Stock in 1998

Formula Capital Study

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Executive Summary

This document reports the results of the Formula Capital Study, a study designed to estimate capital needs for the public housing stock as of 1998 and to support HUD in revising the allocation rules for distributing funds to public housing authorities under the new Capital Fund.

The study focuses on two key measures of need, existing modernization needs and accrual needs.

Existing modernization needs are the costs of repairs and replacements beyond ordinary maintenance required to make the housing decent and sustainable with modest amenities. This includes all capital costs associated with four types of repairs and replacements:

- repairing or replacing systems with immediate repair needs to restore them to working condition, not including costs for routine maintenance;
- additional costs associated with upgrades to some systems, but excluding major reconfiguration of units;
- additions to other systems;
- replacing systems that have reached the end of their useful life, even if they are still in working order.

Accrual needs are the costs needed each year to cover expected ongoing repairs and replacements beyond ordinary maintenance, assuming that existing modernization needs are met.

The estimates of need are based on physical inspections at a sample of 684 developments containing 229,973 units in 219 housing authorities. The inspection sample represents the vast majority of public housing units nationwide—1,194,370 out of the estimated total study universe of 1,206,467 units. Relative to the 1,286,131 units funded under the Comprehensive Grant Program (CGP) and Comprehensive Improvement Assistance Program (CIAP) in FY99, the study universe excludes some 80,000 units slated for demolition or transformation with HOPE VI funding.

Inspections were conducted using updated versions of inspection protocols and costing methods based on those originally developed by Abt Associates Inc. for HUD's 1985 Modernization Needs Study. Due to resource constraints, the inspection protocols did not call for inspecting systems that would allow us to assess modernization costs associated with detecting or abating special hazards such as asbestos or lead paint, modifications for accessibility for the disabled, improvements for increasing energy efficiency, or major reconfiguration of units. Our inspection-based estimates of existing modernization needs do ***not*** include costs for the excluded categories of units listed in the previous paragraph, or for the excluded categories of costs listed above. Even in the 1985 Abt Modernization Needs Study,

asbestos abatement and modifications for accessibility for the disabled were not empirically costed. Cost estimates for lead-based paint and redesign were intended as national estimates and did not enter the 1990 formula. In order to provide a more complete estimate of total national modernization needs, we used the study data to infer costs for the excluded categories of units, and we used external estimates for some of the excluded categories of costs.

The study's key findings on existing modernization needs and accrual needs follow.

Existing Modernization Needs

- The total inspection-based existing modernization needs for the 1,194,370 units included in the inspection universe was $22.5 billion in 1998—an average of $18,847 per unit.
- When estimates for Alaska, Hawaii, Guam, and the U.S. Virgin Islands and for lead-paint abatement, energy efficiency, and modifications for accessibility for the disabled are added, the estimate of existing modernization needs in the total universe of 1,206,467 units increases to $24.6 billion, an average of $20,390 per unit.
- Inspection-based existing modernization needs per unit are correlated with housing authority size. The per-unit average was $13,868 in housing authorities with under 250 units, $17,631 in housing authorities with 250 to 1,249 units, $18,875 in housing authorities with 1,250 to 6,600 units, and $21,462 in housing authorities with over 6,600 units (excluding New York, Chicago and Puerto Rico). Inspection-based existing modernization needs in New York City, Chicago, and Puerto Rico were higher than the national per-unit average—$23,074, $26,184, and $22,172, respectively—and were somewhat higher than in the other very large housing authorities.
- As expected, due to more wear and tear on unit systems, the per-unit inspection-based existing modernization needs were substantially higher in family developments compared with elderly developments, averaging $20,748 versus $12,962.
- One quarter of the stock had inspection-based existing modernization needs below $8,799 per unit. At the high end, one quarter had needs above $26,692 per unit. The median value was $16,908.
- Existing modernization needs appear to have declined substantially since 1990, when HUD last estimated needs in the stock. In 1998 dollars, the total existing unfunded need decreased from about $33 billion in 1990 to about $22 billion in 1998. The decrease was about 35 percent stockwide, and 29 percent on a per-unit basis.

Accrual Needs

- Assuming that the inspection-based existing modernization needs were completely met, each year approximately $2 billion would be required to address ongoing accrual needs or, on average, $1,679 per unit. (No attempt was made to create an estimate of annual accrual needs for the total universe comparable to the estimate of existing modernization needs in the total universe. In other words, accruals were not estimated for the portion of modernization needs not included in the inspection protocol (e.g., modifications for accessibility for the disabled), as was done for the estimate of existing modernization needs in the total universe. The accruals would likely be minimal for systems such as lead paint abatement and asbestos removal.)
- Accrual costs do not vary substantially across properties; the 25th percentile ($1,301) and the 75th percentile ($1,962) are close to the median of $1,627.
- Average annual accrual needs per unit are highest among the smallest housing authorities. This may be due to a combination of several factors. Many of the smaller housing authorities have newer stocks. Further, the stock in smaller agencies is often in better condition than the stock in larger agencies, as can be seen by their lower modernization needs. Our system of modeling accrual assumes that all over-age systems are replaced as part of existing modernization. In newer properties, fewer systems have reached the end of their useful lives, so fewer systems are replaced as part of existing modernization, and more as part of ongoing accrual. As a result, average annual accrual needs are higher, as many systems will reach their life expectancy and need to be replaced over the next 20 years. Also, our accrual modeling assumes that accrual costs are proportional to square feet in the property. Properties in small housing authorities tend to have fewer units per building, and as a result their accrual costs per square foot for major systems are higher than in larger housing authorities. Moreover, as an engineering model (like the model used in the 1990 formula), our accrual model does not take into account neighborhood and climatic conditions that might accelerate physical deterioration in some large housing authorities.
- Accrual costs are higher in family developments, about $1,815 per unit compared with $1,259 per unit in elderly developments.
- Stockwide, annual accrual needs increased by about 1 percent between 1990 and 1998. At a per-unit level the increase was about 10 percent.

Shares of Need Across Housing Authorities

In addition to providing national estimates of need, a second purpose of the study was to provide HUD with information needed to support revision of the formula for allocating capital funds to public housing authorities under the new Capital Fund. This requires estimating capital needs for each development in the stock and summing to the housing authority level. Collecting data for every single development would be prohibitively costly and time-consuming. Instead, as was done for the development of the

CGP formula in the early 1990s, this study adopted the approach of modeling existing modernization needs and accrual needs at the development level based on development, housing authority, and neighborhood characteristics for the nationally representative sample of properties selected for the study. The model-based estimates were applied to the full stock of public housing to obtain development-level estimates of need. The development-level estimates were then summed to create housing authority-level estimates of need.

Using these estimates of need, HUD can allocate its limited resources according to a variety of policy-driven formulas. For example, funds can be allocated in proportion to existing modernization needs, in proportion to accrual needs, or in proportion to some combination of the two. The current CGP formula allocates funds by giving "backlog" (the cost of repairs and replacements beyond ordinary maintenance required to restore all property systems to original working order) and accrual each equal weight. Another alternative could be to provide relatively more funding to housing authorities with higher average needs so that over time they could improve relative to other properties.

Because the 1999 shares allocated under CGP and CIAP result from formulas that approximated the distribution of need as of the mid-1980s, we can compare these shares with the shares of total need derived from the current Formula Capital Study, to get some idea of how relative needs have changed across housing authority groups over the past decade. In order to control the comparison, we will apply the 1999 CGP/CIAP formula patterns of need per unit and the Formula Capital Study patterns of need per unit to the full universe of 1,286,131 units that CGP and CIAP funded in FY99.

- Comparing the 1999 CGP/CIAP shares with the shares of total need derived from the Formula Capital Study indicates that the shares of existing modernization needs and accrual needs have increased among both the small (under 250 units) and medium size (250 to 1,249 units) housing authorities. For example, small housing authorities accounted for 7 percent of the backlog in the CGP/CIAP estimates and 11 percent of existing modernization needs in 1998 under the Formula Capital Study. Medium housing authorities accounted for 18 percent of backlog under the CGP/CIAP allocation and 24 percent of existing modernization needs in 1998 under the Formula Capital Study. Accrual shares also increased somewhat for these categories of housing authorities. This implies that over time the ***relative needs*** of these agencies have grown. In other words, although the average need per unit is still ***lower*** in smaller agencies compared with larger agencies, their needs relative to larger agencies have increased.
- Both existing modernization needs and accrual needs shares remained constant at 26 percent of the total for housing authorities with 1,250 to 6,600 units.
- Among the largest housing authorities (6,600 units or more including New York City, Chicago, and Puerto Rico), relative needs have decreased. On a per-unit basis, their needs are still substantially higher than the needs of the smaller housing authorities, but relatively

their needs have gone down. Under the CGP/CIAP allocation the largest housing authorities accounted for 49 percent of existing modernization needs and 37 percent of accrual needs. The Formula Capital Study estimates that in 1998 these shares have decreased to 39 percent and 31 percent, respectively.

The reasons for the differences in shares across the two periods include:

- The meaning of "existing modernization needs" has been expanded from the original definition of "backlog" to place more emphasis on upgrading systems and replacing all over-age systems that have reached the end of their useful life.
- Some modernization needs have been met since 1985, and probably have been met at a higher rate in housing authorities that showed greater need under the current CGP/CIAP distributions.
- Because they will not remain in the stock in their current configuration, some of the highest need developments (HOPE VI and properties with approved demolition plans) have been excluded from the sample, and thus did not contribute to the Formula Capital Study estimates of per-unit needs.

Further details on the information presented in this Executive Summary are contained in the following report. A summary of the overall Formula Capital Study goals, the sample used for analysis, the data collection procedures, and definitions of technical terms used in this document are presented in Chapter One. Chapter Two provides estimates of capital needs for the public housing stock as a whole and for subgroups of housing authorities. Chapter Three provides details on models that predict measures of need at the development level based on development, housing authority, and neighborhood characteristics. The model-based estimates are applied to the full stock of public housing to obtain property- and housing authority-level estimates of need in order to assist HUD in its revisions of the allocation formula for funding public housing capital needs under the new Capital Fund. Further details on sampling, data collection, the methods used to calculate capital needs from inspection data, and model coefficients are presented in Appendices A, B, C, and D, respectively.

Chapter One:
Overview

Formula Capital Study Overview

This document provides findings from the Formula Capital Study,[1] a study designed to inform revisions to the allocation rules for distributing capital funds to public housing authorities (PHAs), including agencies currently funded under the Comprehensive Grant Program (CGP), and its extension to agencies formerly funded under the Comprehensive Improvement Assistance Program (CIAP).

In order to encourage the comprehensive handling of modernization needs by public housing authorities, Congress enacted in 1991 a Comprehensive Grant Program formula approach to provide funds for modernizing the larger housing authorities (initially 500 or more units, then lowered to 250 or more units). Since 1992 the Comprehensive Grant Program formulas have been the primary mechanism for allocating modernization funding for public housing. The components of this formula system are estimates of capital improvement needs, annual accrual of needs, other sources of funding available to housing authorities, and a range of development characteristics. Although the formula work was debated at every point, the Comprehensive Grant Program formula approach achieved considerable policy and technical acceptance, because it was based on extensive, rigorous statistical testing of a large sample of standardized physical inspections. The multi-billion dollar Comprehensive Grant Program has become the primary source of capital funds for public housing. Other sources of funding for capital needs include the CIAP system for housing authorities with fewer than 250 units. In addition, many large developments that require a relatively higher level of funds to meet their physical and social needs are currently receiving funding under the HOPE VI program.

It is time for a comprehensive review of the Comprehensive Grant formulas. The last standardized inspections of public housing properties took place in the mid-1980s, and the last formula debate took place in the early 1990s. Housing authorities have had about six years of experience with the Comprehensive Grant formulas. The timeliness of re-examining the formulas is made compelling by recent debates in Congress and the Executive Branch over the future of public housing.

1 This work was funded under three separate task orders: Task Order 8 under Contract 18404, Task Order 17 under Contract 18374, and Task Order 14 under Contract 5964.

The goals of the Formula Capital Study were to:

- estimate capital needs nationally and for various categories of housing authorities; and
- provide information for HUD to use in revising the formulas for allocating capital funds to housing authorities under the new Capital Fund program.

In order to assess the CGP formulas, it was necessary to estimate capital needs for a sample of properties and relate the estimates of need to various housing authority and development characteristics. For this study, a nationally representative sample of 684 developments in 219 housing authorities was inspected to obtain estimates of their capital needs. These 684 developments contained 229,973 units, and are representative of the vast majority of units nationwide—1,194,370 out of the estimated total universe of 1,206,467 units. The inspection information was combined with information collected directly from the housing authorities and other secondary databases to create an up-to-date database of capital needs and background information for these developments.

Study Sample and Universe

The data collection was conducted in two phases. Inspections for the original sample of 625 developments were conducted from January through May 1998. In August 1998 HUD decided to expand the sample, focusing on properties in very small housing authorities and properties in the three largest housing authorities—New York City, Chicago, and Puerto Rico. The inspections for the supplemental sample of 59 developments were conducted from November 1998 through January 1999. Further details on sampling are presented in Appendix A.

The initial universe data file received from HUD in August 1997 contained 1,308,050 units. In defining the sampling universe we excluded two categories of developments:

- The study was intended to estimate the capital needs for developments likely to remain in the stock (as compared with developments that will be demolished or replaced through HOPE VI) and to be funded under the Capital Fund. Therefore, developments with approved demolition plans, completed demolitions, or approved HOPE VI implementation grants were ***excluded*** from the sampling universe. For the same reason, Indian Housing Authorities were also excluded from the sampling universe, as they will not be funded through the Capital Fund.
- In order to eliminate prohibitively expensive data collection costs, the sampling universe ***excluded*** developments in Alaska, Hawaii, Guam, and the U.S. Virgin Islands. For the same reason, the sampling universe also ***excluded*** all developments explicitly identified as

scattered-site in HUD's master universe file.

After the exclusions described above, the sampling universe consisted of 1,178,003 units in 12,611 developments in 3,144 housing authorities. While on site, the inspectors identified additional properties that should have been excluded because they received 1998 HOPE VI implementation grants or were no longer public housing. Following these additional exclusions, the final estimated sampling universe was 1,133,963 units.

To provide a more complete picture of national needs, we have adjusted the sample weights and made other adjustments so that the sample represents all developments and units likely to be funded through the Capital Fund. The first adjustment included adding back into the universe scattered-site developments, units in HOPE VI developments that are not included in the HOPE VI program, and any units not slated for demolition in developments with approved demolition plans, bringing the inspection universe of units to 1,194,370. Units not in the original sampling universe were "brought back" to the inspection universe by increasing the weights for similar categories of properties that were included in the sampling universe. We then added in all units in Alaska, Hawaii, Guam, and the U.S. Virgin Islands. Our all-inclusive estimated universe for the total projections of need is 1,206,467 units. Again, note that this "universe" of 1,206,467 units excludes almost 80,000 units either approved for demolition or funded by HOPE VI implementation grants, that were funded by the FY99 CGP. Further details are presented in Appendix A.

Data Collection and Methodology Summary

In order to assess and revise the CGP formulas, it was necessary to estimate capital needs for a sample of properties and relate the estimates of need to various housing authority and development characteristics for the sample. To do so, we needed a range of housing authority- and development-level data. A database on the characteristics of the sample properties has been assembled from three major sources:

- on-site inspections conducted by trained architects and engineers from the DLR Group using the Observable Systems Approach to estimate capital needs;
- existing computerized datasets from HUD (containing data on developments and housing authorities and their residents);
- existing background data obtained directly from housing authorities (e.g., modernization spending and plans), which was obtained using a data abstraction form.

The information contained in this database was used to estimate property-level, housing authority-level and national capital needs, and to develop alternative formulas for allocations. Further details on data collection are provided in Appendix B.

On-Site Inspections

Capital needs were assessed by inspectors using the Observable Systems Approach developed by Abt Associates Inc. The approach was initially developed by Abt Associates Inc. for the 1985 HUD Modernization Needs Study and was refined by Abt Associates Inc. for several later studies including the 1990 Assessment of HUD-Insured Multifamily Housing Stock, the 1991 Assessment of Capital Needs for the San Francisco Housing Authority, and the 1995 Assessment of the HUD-Insured Multifamily Housing Stock.[2] The Observable Systems Approach combines on-site inspection and rating of a property's condition with a computerized costing system based on a consistent set of repair/replacement costs that are adjusted for regional price differences.

The term "observable systems" is used to indicate that the physical condition of the system is capable of being observed and assessed in the field, and that "destructive" testing is not involved (e.g., opening up a wall to check for insulation or broken pipes). In certain instances the observation is a judgement, based on knowledge of the conditions of such systems, modified by whatever data (either inferred or provided) are available at the site. The main advantage of the Observable Systems approach is that it is a cost-effective way to estimate property and national needs using a sample of units and buildings from a nationally representative sample of developments.

The inspection protocol included observing 135 mechanical, electrical, and architectural systems in a sample of units and buildings in the property and for the site as a whole. A "system" is defined as an observable component at the site, building, unit, or project level. Unit systems include interior construction (walls, partitions, floor sub-bases), interior finishes (wall surfaces, floor coverings, interior doors), kitchen fixtures (cabinets, ranges, refrigerators), bathroom fixtures (toilets, vanities, tubs), and unit-level mechanical and electrical systems (heating, cooling, electrical, and communication systems). Building systems include building exterior closures (foundation, slab, exterior wall, insulation), exterior features (canopies, exterior stairs, building-mounted site lights, fire escapes, balconies, porches, decks, sheds), and building mechanical systems (boilers, switchgears, heating risers, etc.). Central facility systems include central facility interior construction (common room interior, laundry room interior, mail facility interior, restroom interior, etc.) and central facility equipment (laundry equipment, central kitchen and bath fixtures, and mail facilities). Site systems include site areas (landscaping, roadways, parking

2 Dixon Bain et al., *Study of the Modernization Needs of the Public and Indian Housing Stock* (Cambridge, MA: Abt Associates Inc., March 1988); James Wallace et al., *Current Status of HUD-Insured (or Held) Multifamily Rental Housing* (HUD, PD&R 1993); Judie Feins et al., *Viability Review for Physical Improvements for the San Francisco Housing Authority* (Cambridge, MA: Abt Associates Inc., September 1991); Meryl Finkel et al., *Status of HUD-Insured (or Held) Multifamily Rental Housing in 1995* (Cambridge, MA: Abt Associates Inc., December 1998). Details on the precise protocols and forms used for the current study are provided in the HUD Formula Capital Study *Inspection Manual* (Abt Associates Inc., January 1998).

lots, parking garages, paved pedestrian areas, curbing, fencing, retaining walls, site drainage, pole-mounted site lighting, etc.), site amenities (basketball courts, site furniture, dumpsters and enclosures) and site distribution systems. Full details on systems and system groupings are presented in Exhibit C-2 in Appendix C.

The term "action level" refers to the level or nature of the repair required to restore the system to its original condition. For each observable system the inspector chooses among five action levels, each of which has a specific set of sub-actions associated with it. The five action levels are:

- No Action Required
- Minor Action Required
- Moderate Action Required
- Major Action Required
- Replacement Required

Each action level is precisely and objectively defined for the system in question, so that assessments can be consistent across inspectors. The inspection booklets were developed based on these systems and actions. The inspection instruments require inspectors to record their evaluations of condition by indicating which of five ordinal categories most accurately describes the nature of the improvement needed. For any system, each action level denotes a specific repair action. For example, for ranges and hoods (a dwelling unit system), the Minor (MIN) action is to replace a burner and clean the hood; the Moderate (MOD) action is to replace the hood; the Major (MAJ) action is to replace the range; and Replacement (REP) involves replacing the range and the hood. Not all systems have five action levels. For example, for refrigerators, the only action is REP, which replaces the refrigerator. The ***Inspection Manual*** for this study details each allowable action level for each system.

For some systems, in addition to identifying immediate repair needs for that system, a determination was made as to whether the system needed any additions or upgrades in order to ensure that the housing was decent and sustainable. Two tools were used to help the inspector make this determination. The first was direct observations and discussions with the property escort about the various systems. (Housing authorities were instructed to provide an escort who was familiar with the property's systems.) The second tool was the Summary Project Observations and Windshield Survey (SPOWS) form. This form was used to record general descriptions of the development and the surrounding neighborhood, allowing the inspector to place the inspected property in context within its neighborhood. To complete the Windshield Survey component of the SPOWS, the inspector was to spend approximately 15 minutes driving around the neighborhood making the necessary observations. Inspectors were instructed to pay particular attention to the characteristics of other low-income housing in the neighborhood.

With this information in hand, the inspector was then asked to assess the feasibility of upgrading or

adding selected systems. In several of the inspection booklets (Building Envelope, Building Mechanical and Electrical, Unit and Site), the inspector was to determine whether by some investment beyond routine repairs, a property or system should be upgraded to be more comparable to other housing in the neighborhood. These determinations were based on direct observations of the system (age, technology, evidence of repair problems, etc.), discussions with the property escort about the various systems, and the observations made while completing the SPOWS. Examples of systems that could be upgraded or added include: windows, stairways, common rooms, laundry rooms, air conditioning, site parking, site lighting, landscaping, fencing and playgrounds. Determinations of unit upgrade actions were slightly different as they were based on broad assessments of three living areas (kitchen, bathrooms, unit interior) instead of individual system-level judgements. All upgrade determinations involved a series of questions asking first whether the upgrade was necessary and second whether the upgrade was feasible.

Depending on the system assessed, the inspector determined the upgrade action recommended:

- current system did not need to be changed;
- current system needed to be upgraded with higher quality materials, such as windows that needed to be upgraded to thermopane glass;
- current system needed to be upgraded with higher quality materials and expanded, such as site furniture that needed to be upgraded using better materials, and then needed to be expanded in terms of numbers;
- current system did not need to be upgraded, but should be expanded, such as site parking areas that did not require upgrading, but more spaces needed to be produced;
- system was not present but should be added, such as central air conditioning.

The system's age was recorded for many systems. Age was determined through observation of the system and conversations with the property escort. If age was unknown the system was given the same age as the building or property. System age also indicates at what point the system is in its expected life cycle, and is important in the accrual calculations which are based on a system's useful life. For each accrual year (years 2-20) the system's age is increased by one year. In any year that a system's accrual age equals its expected life, the repair/replace cost is added into the accrual total for that year.

After the inspection data was converted to electronic form, Abt Associates Inc. applied a set of repair, replacement, or upgrade costs to each item inspected. All costs in the cost file are for the Washington, D.C. metropolitan area and include costs of labor, materials and contractor fees. Using the precise definitions of the action levels described above (and further in the Inspection Manual), a series of costs were developed for each action level, for each system, that reflect materials commonly used in public or low-income housing. These costs were developed by Abt Associates Inc. with the assistance of a specialized costing contractor, A.M. Fogarty & Associates, Inc. In the above example for ranges and

hoods, the MIN cost is $108 for each kitchen requiring MIN action (replace a burner and clean the hood); MOD costs are $246 for each kitchen requiring a MOD level of repair (replace the hood); MAJ costs are $480 for each kitchen (replace the range); and REP costs are $720 (replace the range and hood).

If the inspector indicated that a system requires upgrading—or in the case of the unit, that a particular area requires upgrading—and that it is feasible to do so, the cost associated with the upgrade is usually used instead of the cost for the repair action. For example, if the kitchen needs upgrading, the cost to do a partial upgrade, which upgrades *some* of the kitchen systems is $5,180. (The systems in the kitchen include the walls, ceiling, floor covering, cabinets, sink, range and refrigerator.) The cost for a full upgrade, which upgrades *all* the kitchen systems, is $7,680. The cost for a kitchen rehab, which includes upgrading all the kitchen systems and moving partitions, is $15,180. When both upgrade and repair actions are indicated, the more expensive cost is applied. Costs for each action level for each system and the costs for upgrading or adding selected systems are presented in Exhibit C-1 in Appendix C.

Once the property-level costs were estimated, they were multiplied by two adjustment factors. First, they were adjusted for local cost variations using the R.S. Means locational adjustment factors. Second, they were adjusted by a factor of 7 percent to account for soft costs (design costs and architect and engineering costs) and by a factor of 10 percent to account for housing authority management costs.[3]

From these, we developed dollar estimates based on capital needs for the sampled developments and computed the capital needs estimates for the inspection universe of public housing. We refer to these costs as the ***"inspection-based existing modernization needs for the inspection universe."*** These inform our analysis of the reliability and funding impact of formula funding proxies across types of housing authorities. The cost estimation procedures are described in more detail in Appendix C.

Inspectors ***did not*** make any observations relating to:

- detecting or abating special hazards such as presence of asbestos or lead paint;
- modifications for accessibility for the disabled;
- improvements for increasing energy efficiency; or
- major redesign or reconfiguration of units.

Thus, our inspection-based cost estimates do not include these repairs. Costs for routine maintenance items such as maintaining elevators, cleaning gutters and chimneys, or replacing missing outlets and light

3 No adjustments to costs were made for contingencies and unforseen circumstances.

fixtures are also not included in the inspection-based modernization cost estimates. The 1990 formula estimates also excluded maintenance items and capital cost categories for lead-based paint abatement, access for the disabled, energy efficiency, and major redesign. (Estimates of costs of abating lead paint, modifications for accessibility for the disabled, and improvements for increasing energy efficiency needs were added to the inspection-based estimates to obtain ***estimates of existing modernization needs for the total universe***.)

Background Data Provided by the Housing Authorities

A data abstraction form was mailed to all housing authorities in the sample to obtain data on past and future spending for modernization, as well as certain descriptive characteristics of the housing authority and its developments in the sample. Since many of the data items requested were taken directly from the Comprehensive Grant Program application, housing authorities were requested to complete the form or attach the relevant parts of that documentation to the form.

The form collected three types of data:

- descriptive data on total units managed under Federal and non-Federal programs, and any special management arrangements in place (e.g., private management or receivership);
- modernization history and plans for the next five years for the housing authority; and
- modernization history and plans for the next five years for each sampled development.

Secondary Datasets

Existing computerized datasets from HUD (containing data on developments, housing authorities and their residents) were used to create a sampling universe and provide descriptive characteristics of housing authorities and their developments, such as development age, size, vacancy rates, and modernization history. These secondary datasets include HUD's Public and Indian Housing (PIH) master files, PIH Integrated Business System (IBS), Public Housing Management Assessment Program (PHMAP) data, the 1998 Picture of Subsidized Households (a HUD database in the HUD User website that offers a variety of resident and neighborhood data on each development in the stock), and the 1990 Census data files. Additional details on these datasets are provided in Appendix B.

Technical Terms Used in the Study

This document uses several different definitions of capital needs as well as several different “universes”

for estimating these needs. To avoid confusion, we present definitions of each term below. Although the complete terms are somewhat cumbersome, we feel that using the full terms throughout the document will help to maintain the distinctions. The terms will also be used in context in the chapters that follow, so that the reader might proceed directly to Chapter Two and refer back to this glossary as needed.

Universe Definitions:

Sampling Universe. Universe of units included in the study sampling frame. This included the vast majority of public housing units. We excluded all units in Alaska, Hawaii, Guam and the U.S. Virgin Islands, all units in properties that received HOPE VI implementation grants or had demolitions plans approved as of 1998, and all units in scattered-site and Turnkey properties. Our estimate of the sampling universe is 1,133,963 units.

Inspection Universe. Universe of units included in the inspection-based estimates of need. This is the sampling universe plus units in scattered-site developments, units in HOPE VI developments that are not included in the HOPE VI rehabilitation, and any units not slated for demolition in developments with approved demolition plans. The total inspection universe includes 1,194,370 units and was derived by re-weighting the sample of developments selected for the sampling universe.

Total Universe. This is the universe of units that includes all units in the inspection universe plus 12,097 units in Alaska, Hawaii, Guam and the U.S. Virgin Islands. Our estimate of the total universe includes 1,206,467 units.

CGP/CIAP Universe. This includes all 1,286,131 public housing units from HUD's 1999 CGP and CIAP universe files. This is the universe HUD funded in its most recent formula allocation. Therefore it is used in analyses that compare shares of need based on the study's model-based estimates with the current CGP/CIAP shares. The number differs from the Total Universe estimate primarily because the CGP/CIAP universe includes units slated for demolition and units slated for transformation under HOPE VI.

Estimates of Existing Modernization Needs:

Direct Estimate of (Inspection-Based) Existing Modernization Needs in the Inspection Universe. This measure of existing modernization needs is obtained by multiplying the estimate of existing modernization needs per unit for each inspected sample property by its sampling weight. Because the sum of the weights equals the inspection universe of 1,194,370 units, the weighted sum of the estimates of existing modernization needs equals a national estimate of existing modernization needs. This estimate includes only inspection-based needs, and does not include categories of need such as lead paint abatement, energy efficiency, and disabled access. For simplicity, in the document this is

termed the "direct estimate of existing modernization needs."

Estimate of Existing Modernization Needs in the Total Universe. For the 1,206,467 units in the total universe, this national estimate adds to the direct estimate of inspection-based existing modernization needs in the inspection universe, estimates to account for several categories of need not included in our inspection protocols (lead paint abatement, unit-level energy efficiency, disabled access) and the categories of properties not included in the inspection universe (12,097 units in Alaska, Hawaii, Guam, and the U.S. Virgin Islands).

Model-Based Estimates of Existing Modernization Needs for the Inspection Universe. This measure of inspection-based existing modernization needs is based on statistical modeling. The model first relates development-level existing modernization needs to development, housing authority, and location characteristics. The estimated equation derived from the sample developments is applied to each property in the inspection universe of 1,194,370 units and in the CGP/CIAP universe of 1,286,181 units.

Estimates of Accrual Needs:

Estimate of Annual Accrual Needs in the Inspection Universe. This measure of accrual needs is parallel to the direct estimate of inspection-based existing modernization needs in the inspection universe. It is obtained by multiplying the estimate of accrual for each inspected sample property by its sampling weight.

Estimate of Accrual Needs in the Total Universe. No attempt was made to provide national total estimates of accrual that take into account the categories of need excluded from the inspection protocol, or the categories of properties excluded from the inspection universe.

Model-Based Estimates of Accrual. This measure of accrual needs is parallel to the estimate of existing modernization needs in the total universe. The models were developed using the inspection sample, and the results were applied to both the inspection universe and the CGP/CIAP universe.

Chapter Two:
Measures of Capital Needs

This chapter focuses on the two fundamental measures of capital needs used for this study, existing modernization needs and accrual needs. These measures are used to produce direct estimates of existing modernization needs for the inspection universe and the direct estimates of existing modernization needs for the total universe. This chapter focuses on the direct estimates of need—in other words, the estimates that were obtained by weighting the study sample estimates to obtain estimates for the inspection universe.

Measures of Need

Existing modernization needs equal the costs of repairs and replacements beyond ordinary maintenance required to make the housing decent and sustainable with modest amenities. This includes all capital costs associated with four types of repairs and replacements:

- repairing or replacing systems with immediate repair needs to restore them to working condition, not including costs for routine maintenance;
- additional costs associated with modest upgrades to some systems;
- additions to other systems such as those described below; and
- replacing systems that have reached the end of their useful life, even if they are still in working order.

An example of a system where the modernization cost is an immediate repair is "roadways." The modernization cost for roadways would be the cost of repairing and replacing deteriorated portions of the roadways.

Systems that may require upgrades whether or not immediate repairs are required include landscaping, kitchens, bathrooms, and windows. Even if these systems are in working order, modest upgrades may be required to make the housing decent and sustainable with modest amenities.

Systems that may require additions as part of existing modernization needs include parking areas, central air conditioning, window security grates, and tot lots. These systems may or may not be present initially. More parking spaces, a tot lot, or central air conditioning may be needed to make the housing decent and sustainable with modest amenities.

Systems that may need to be replaced because they have reached the end of their useful life include roofs and boilers. For example, a unit boiler that is over 25 years old may still be in working order, but is likely to fail soon and should be replaced as part of a modernization effort.

System repair costs were obtained from A.M. Fogarty & Associates, Inc., a firm with extensive experience in costing for private and public housing construction and modernization. Using the precise definitions of the action level repair actions, they developed a series of costs for each action level for each system that reflect the materials commonly used for public and low-income housing. Costs are for the Washington, D.C. metropolitan area (and adjusted for other locations using the R.S. Means Location Adjustment factor at the zip code level), and include parts, labor and contractor fees for the modernization project. Costs do not include soft costs such as design costs, architect and engineering costs, and costs associated with PHA management of the modernization process. These latter categories were accounted for through an adjustment factor of 17 percent added to the measures of need.

As noted in the previous chapter, the inspections did not include observations on the costs of detecting or abating special hazards such as asbestos or lead paint, modifications for accessibility for the disabled, unit reconfiguration, or improvements for increasing energy efficiency. Thus, our inspection-based measures of need do not include these components. For the estimate of existing modernization needs in the total universe presented later in this chapter, we have added approximations for some of these components based on the best available data on incidence and costs.

Accrual needs equal the costs needed each year to cover expected ongoing repairs and replacements beyond ordinary maintenance, assuming that the existing modernization needs are met. Accrual costs were calculated for each of the 20 years following the current modernization using the following methodology. Each of the 135 observed systems[1] was assigned an "accrual interval" and an "accrual action" depending upon the standard wear of the system. Accrual intervals and accrual actions were compiled by Abt Associates Inc. from industry standards and earlier work by Abt Associates Inc. and ICF, Inc., and were carefully reviewed by several outside experts and housing authority representatives for a recent HUD study on the capital needs of the HUD-insured multifamily housing stock. They were also adjusted based on input from a group of members of the Capital Fund Negotiated Rulemaking Committee. The *accrual interval* is the interval at which a periodic replacement or repair of the system is required. As described in Appendix C, for some systems such as kitchen appliances and carpets, accrual intervals depend on property occupancy. They are shorter for family developments than for elderly developments. For other systems, such as yards and screen doors, useful lives are shorter in high-density family buildings than in lower-density family buildings. For some unit systems, such as

1 Some systems were deemed inappropriate for accrual estimates because they generally will not need replacement or standard maintenance over the 20-year horizon for this study (for example, site distribution systems), or are considered maintenance items (for example, painting interior walls).

flooring, useful lives were lower the greater the number of bedrooms (and, typically, occupants in the unit). The accrual system does not take account of differences in climate, or neighborhood density, or distress. The *accrual action* is the action that is undertaken at the accrual interval (e.g., replacement or major repair). For example, boilers are expected to be replaced after a certain number of years, but landscaping only needs periodic minor maintenance.

For each of the next 20 years, depending on each system age and accrual interval, our model assessed whether an action needed to be undertaken for that system in that year, and then used the accrual actions and their associated costs to estimate annual accrual costs. System age for each of the observed systems was recorded by the inspector at the time of the inspection. Moderate repair, major repairs, replacements, upgrades, and additions undertaken as part of addressing existing modernization needs reset system ages to zero. In any year that a system's accrual age equals its expected life, then the repair/replace cost is added into the accrual total for that year. Accrual costs were estimated only for the systems included in the inspection-based components of national need and were calculated in 1998 dollars.

Inspection-Based Measures of Need

Housing authorities are divided into the following categories for analysis:

- All housing authorities
- All housing authorities except New York City, Chicago, and Puerto Rico
- Housing authorities with less than 250 units
- Housing authorities with 250 to 1,249 units
- Housing authorities with 1,250 to 6,600 units
- Housing authorities with more than 6,600 units (except for New York City, Chicago, and Puerto Rico)
- New York City Housing Authority
- Chicago Housing Authority
- Puerto Rico Housing Authority

Exhibit 2-1 presents our ***direct estimates of the measures of existing modernization needs*** for the 1,194,370 units in the ***inspection universe***. All dollar values are locally adjusted using the RS Means adjustment factor by zip code, reflecting local 1998 costs. To facilitate comparing physical needs across properties having different numbers of units, all property costs are expressed on a "per-unit" basis. ***Direct estimates of existing modernization needs in the total universe***, including estimates for the uninspected categories of units and costs, are presented in Exhibit 2-2, later in this chapter.

Exhibit 2-1: Direct Estimates of the Measures of Need For the Inspection Universe

Housing Authority Size	All	All (except NYC, Chicago, PR)	<250 Units	250-1,249 Units	1,250-6,600 Units	6,600+ Units (except NYC, Chicago, PR)	NYC	Chicago	Puerto Rico
Sample Properties									
Overall	684	568	126	187	177	78	50	21	45
Elderly	178	169	34	57	57	21	1	8	0
Family	506	399	92	130	120	57	49	13	45
Inspection Universe Units[a]	1,194,370	952,638	197,525	342,347	291,365	121,401	156,432	32,177	53,123
CGP/CIAP Units	1,286,131	1,030,191	203,687	336,648	342,266	147,590	160,209	38,788	56,943
Direct Estimates of the Existing Modernization Needs, per Unit									
Means									
Overall	$18,847	$17,720	$13,868	$17,631	$18,875	$21,462	$23,074	$26,184	$22,172
Elderly	$12,962	$12,624	$10,595	$13,272	$13,050	$13,379	$19,910	$20,149	—
Family	$20,748	$19,823	$15,340	$19,439	$21,387	$23,991	$23,139	$28,935	$22,172
Median	$16,908	$15,681	$12,693	$15,675	$16,801	$18,771	$22,915	$26,740	$21,486
25th Percentile	$8,799	$8,273	$7,023	$8,799	$8,687	$11,901	$9,399	$19,263	$12,671
75th Percentile	$26,692	$25,117	$20,652	$24,281	$27,852	$29,942	$30,627	$33,074	$28,574
Total across All Units	$22,510,219,390	$16,880,288,094	$2,739,322,131	$6,035,998,697	$5,499,493,979	$2,605,490,052	$3,609,527,611	$842,514,846	$1,177,843,156
Average Annual Accrual Years 1-20, per Unit									
Means									
Overall	$1,679	$1,668	$1,821	$1,640	$1,645	$1,554	$1,918	$1,346	$1,379
Elderly	$1,259	$1,270	$1,486	$1,212	$1,217	$1,176	$999	$1,029	—
Family	$1,815	$1,832	$1,971	$1,818	$1,830	$1,672	$1,936	$1,490	$1,379
Median	$1,627	$1,597	$1,721	$1,588	$1,547	$1,410	$1,896	$1,312	$1,312
25th Percentile	$1,301	$1,272	$1,386	$1,241	$1,204	$1,103	$1,697	$1,018	$1,176
75th Percentile	$1,962	$1,958	$2,021	$1,934	$1,918	$1,824	$2,163	$1,623	$1,487
Total across All Units	$2,005,347,230	$1,589,171,659	$359,608,089	$561,579,172	$479,379,921	$188,600,096	$299,984,953	$43,298,980	$73,256,617

a Excludes units approved for demolition or HOPE VI, and excludes all units in Alaska, Hawaii, Guam, and the U.S. Virgin Islands. The size categories are based on the number of units in the housing authority after exclusion of units. Thus, some housing authorities that currently are in one size category in the CGP/CIAP universe are in a different size category in the inspection universe. Thus, the number of units in the two universes are not perfectly comparable across housing authority sizes.

For each category of housing authorities the following information is presented:

- Total number of sample properties.
- Total sample properties defined as elderly (average bedrooms per unit less than 1.5, except when average bedrooms per unit is between 1.2 and 1.5 and the property has more than 100 units with 2 or more bedrooms).
- Total sample properties defined as family (average bedrooms per unit at least 1.5, or any property with an average bedrooms per unit between 1.2 and 1.5 and at least 100 units with 2 or more bedrooms).
- Estimate of the inspection universe based on the weighted inspection sample.
- 1999 CGP/CIAP universe. This differs from the inspection universe because the CGP/CIAP universe counts units with approved HOPE VI or demolition plans, as well as units in Alaska, Hawaii, Guam, and the U.S. Virgin Islands. In addition, the study universe is based on 1997 data and the CGP/CIAP universe is based on 1999 data.

For each capital needs measure the following statistics are presented:

- Mean across all units.
- Mean for units in elderly properties.
- Mean for units in family properties.
- Median, 25th percentile, and 75th percentile across all units.
- Total across all units (equals the overall mean multiplied by the number of units in the universe).

Direct Estimates of Existing Modernization Needs for the 1,194,370 Units in the Inspection Universe

- The national average of the direct estimate of existing modernization needs in the inspection universe was $18,847 per unit, with a median of $16,908 per unit.

- The average per-unit direct estimate of existing modernization needs is correlated with housing authority size. The average direct estimate of existing modernization needs was $13,868 in housing authorities with under 250 units, $17,631 in housing authorities with 250 to 1249 units, $18,875 in housing authorities with 1,250 to 6,600 units, and $21,462 in housing authorities with over 6,600 units (excluding New York, Chicago and Puerto Rico). The per-unit direct estimates of existing modernization needs in New York City, Chicago, and Puerto Rico were

higher than the national average: $23,074, $26,184, and $22,172, respectively, and were somewhat higher than in the other very large housing authorities.

- The 25th and 75th percentiles provide indications of the overall distribution of needs. Nationwide, one quarter of the units had direct estimates of existing modernization needs of under $8,799 per unit and one quarter had needs over $26,692 per unit. The median value was $16,908.
- As expected, the average per-unit direct estimate of existing modernization needs is substantially higher in family developments compared with elderly developments, $20,748 versus $12,962.

Direct Estimates of Average Annual Accrual Years 1-20 for the 1,194,370 Unit Inspection Universe

- Exhibit 2-1 presents the average annual accrual needs over years 1 to 20 in 1998 dollars. Nationwide, assuming that the inspection-based existing modernization needs were completely addressed, each year approximately $2 billion would be required to address the ongoing accrual needs, or on average, $1,679 per unit.
- Accrual costs do not vary substantially across properties; the 25th percentile ($1,301) and the 75th percentile ($1,962) are close to the median ($1,627) and average ($1,679).
- In Chicago and Puerto Rico, the per-unit average annual accrual was slightly less than the national average, $1,346 and $1,379, respectively. The reason accrual needs in Chicago are less than the national average is because many of their systems need to be replaced as part of the modernization effort. Thus, in the first few years following modernization, accrual costs are low. In Puerto Rico, several expensive systems that were missing from the housing stock, such as domestic hot water generators, window upgrades, unit air conditioners, unit refrigerators, and unit ranges were assumed to be added to the existing modernization needs to make the housing stock more comparable to the rest of the nation. These systems will not incur accrual costs until they reach the end of their useful life, a useful life that sometimes exceeds the 20-year cutoff of our model.
- Except for New York City, average annual accrual needs per unit are highest among the smallest housing authorities. This may be due to a combination of several factors. Many of the smaller housing authorities have newer stocks. Further, the stock in smaller agencies is often in better condition than the stock in larger agencies, as can be seen by their lower modernization needs. Our system of modeling accrual assumes that all over-age systems are replaced as part of existing modernization. In newer properties, fewer systems have reached the end of their useful lives, so fewer systems are replaced as part of existing modernization, and more as part

of ongoing accrual. As a result, average annual accrual needs are higher, as many systems will reach their life expectancy and need to be replaced over the next 20 years. Our accrual modeling also assumes that accrual costs are proportional to square feet in the property. Properties in small housing authorities tend to have fewer units per building, and as a result their accrual costs per square foot for major systems are higher than in larger housing authorities. Moreover, as an engineering model (like the model used in the 1990 formula), our accrual model does not take into account neighborhood and climatic conditions that might accelerate physical deterioration in some large housing authorities.

- Accrual costs are higher in family developments, about $1,815 per unit compared with $1,259 per unit in elderly developments.

Estimates of Existing Modernization Needs for the Total Universe

As noted earlier, the direct estimates of existing modernization needs in the inspection universe do not include all categories of units or all categories of modernization costs. Exhibit 2-2 presents our best estimate of existing modernization needs for the total universe as a whole. This estimate of existing modernization needs for the total universe includes the inspection-based measure of needs plus estimates to account for the categories of need (e.g., lead paint abatement) and categories of properties (e.g., Alaska, Hawaii) not included in our inspection protocols. The estimate of existing modernization needs in the total universe is 24.6 billion. Exhibit 2-2 presents the estimate for the additional units for Alaska, Hawaii, Guam and U.S. Virgin Islands, and those for lead paint abatement, accessibility for the disabled, and energy efficiency.

Exhibit 2-2: Estimates of Existing Modernization Needs for the Total Universe [a]

Estimate of existing modernization needs in the inspection universe (for 1,194,370 units in the inspection universe)	$22,510,291,390
Addition for Alaska, Hawaii, Guam and U.S. Virgin Islands	$248,283,650
Addition for lead paint abatement	$1,118,000,000
Addition for accessibility for the disabled	$358,311,000
Addition for energy efficiency [b]	$361,934,700
National estimate of total existing modernization needs	$24,596,820,740

a Does not include estimates for asbestos removal or for major reconfiguration of units. Also excludes $3 billion of pipeline funding not yet expended.

b Only includes costs for unit-level actions to improve energy efficiency.

Estimate for Alaska, Hawaii, Guam, and the U.S. Virgin Islands: Our estimate of needs for each of these locations equals the actual number of units in the location multiplied by the national average inspection-based modernization needs per unit, multiplied by the ratio of 1999 CGP amounts per unit for the site relative to the national average. For example, Alaska had 1,335 units of public housing. The average direct estimate of existing modernization needs for the inspection universe per unit is $18,847. The 1999 CGP amount per unit for Alaska was $2,502 and the national average was $2,251. Thus our estimate of existing modernization needs for Alaska equals 1,335 x $18,847 x ($2,502/$2,251) = $27,966,319.

Estimates for lead paint abatement: HUD estimates that as of the end of 1998 lead paint needed to be abated in about 430,000 units.[2] Assuming that abatement is part of an overall modernization effort, the estimated cost per unit is about $2,600, for a total universe cost of $1.118 billion.[3]

Estimates of costs for accommodating persons with disabilities: These costs vary significantly depending on the specific conditions of the unit and on other work being conducted. On one hand, if other modernization work is being undertaken, the costs can be minimal. On the other hand, it can reportedly cost over $20,000 per unit in other circumstances. Our conversations with numerous housing authorities and other experts led to a rough total universe estimate of about $10,000 per unit. Overall the requirement is to make 5 percent of all units accessible during a modernization effort. Assuming that 2 percent are already accessible, we estimate that 3 percent of all units require action, for a total of 36,194 units at a cost of $358,311,000.

Estimates of modernization to improve energy efficiency: As with other costs, the costs for improving unit energy efficiency vary greatly depending on the particular circumstances of the unit and building. A "typical" retrofit package including low-cost lighting, weatherstripping, low-flow faucet aerators and showerheads, water heater pipe insulation, water heater tank wraps, thermostats, storm windows, air sealing, and attic insulation can cost about $680 to $1,000 per unit. A more intensive package including some window replacements costs about $2,500 per unit.[4] Without making direct on-site observations, we estimate that because many units are undergoing modernization, on average an additional $300 per unit would be required to improve unit energy efficiency, for a total universe estimate of $361,940,000.

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2 Based on information provided by Stevenson P. Weitz from HUD's Office of Lead Hazard Control.

3 If abatement is not part of an overall modernization effort, costs will be higher, about $5,500 per unit. Costs will also be higher if the work is delayed beyond three years. If the work is delayed beyond three years, there are requirements for risk assessments and costly interim measures.

4 Based on costs from Goldman, C., K.. Greely, and J. Harris, *Retrofit Experience in the U.S. Multifamily Buildings: Energy Savings, Costs, and Economics*, Volume II. (Berkeley, CA: Lawrence Berkeley Laboratory, Applied Science Division, 1998.) Adjusted for inflation.

Estimates of costs for removing asbestos hazards: Estimates of the costs of removing asbestos hazards range from about $8.75 per square foot (for vinyl asbestos tile) to $11.35 per square foot (for cement asbestos board). Our inspections show that an average 2-bedroom public housing unit is about 750 square feet, thus the asbestos removal cost is about $6,560 to $8,500 per unit requiring action. We have not been able to obtain any estimates on the number of units requiring action, so for the current estimates ***we have not included*** the cost of removing asbestos.

Unexpended funds: The estimates of existing modernization needs reflect observed condition and costs as of mid-1998. They ***do not take into account*** the approximately $3 billion of modernization funds from FY1997 and earlier, available but not expended as of the time of the inspections in mid-1998.

Comparing 1990 and 1998 Estimates of Needs[5]

A natural question is how the estimated needs of the stock in mid-1998 (the mid-point of inspections in this study), compare with the estimated needs of the stock in January 1990 (the date of estimates of backlog and accrual need used in the HUD study that shaped the current Comprehensive Grant formulas). This section first compares estimates of existing modernization needs and then compares accrual estimates.

Comparing 1990 and 1998 Estimates of Existing Modernization Needs

Although the specific categories and definitions of need vary in the two studies, the basic concepts are close enough that a comparison is meaningful. The 1990 national estimates of unfunded backlog included several elements. The largest cost element was the Mandatory Backlog Need, which included all costs associated with repairing or replacing all non-working systems in the stock. In addition to Mandatory Repairs, the unfunded backlog included a series of Project Specific Additions that were identified by the housing authorities in the study and were agreed to by the inspectors.[6] As described above, the current study's estimates of existing modernization needs include all costs associated with repairs and replacements, upgrades and additions to some systems, and replacement of all over-age systems, i.e., systems that have reached the end of their useful life.

Comparing the 1990 and 1998 estimates of modernization needs for the inventory requires that adjustments be made to each of the estimates. In adjusting the 1990 data, the first step is to inflate the

5 For this analysis we had assistance from HUD staff.

6 See *Report to Congress on Alternative Methods for Funding Public Housing Modernization* (Washington, DC: U.S. Department of Housing and Urban Development, April 1990).

1990 dollars to mid-1998 levels using a 27 percent Consumer Price Index (CPI) cost-of-living adjustment factor. A second step is to add 5.4 percent to the 1990 data for soft costs, bringing the 1.11 multiplier for soft costs in 1990 to 1.17, the figure used in the 1998 study. A final step is to add to the 1990 backlog an estimate of $6.64 billion for over-age systems past their useful life—$6.64 billion was the amount that inspections and accrual models tallied in the 1998 study. In 1990 over-age systems were included in the accrual account, even though it now seems more appropriate to treat over-age systems as existing modernization because most of them probably fail within several years after an inspection date or are repaired under comprehensive modernization.

At the same time, the 1998 data can be made more comparable to the 1990 categories of need by representing the data as unfunded need in mid-1998, just as the 1990 data represented unfunded need in January 1990. To represent unfunded need in 1998, the estimates of existing modernization need in the 1998 study are reduced by $3 billion, which is the amount of Comprehensive Grant and CIAP funds from FY97 and earlier years that were unexpended as of mid-1998. The $3 billion is deducted from the categories of existing modernization need in proportion to their share of total need prior to the deduction.

As a result of the adjustments, the 1990 and 1998 data become more comparable. The existing need for 1998 and the backlog need for 1990 both consist of essential repairs, upgrades, and additions; appropriate repairs for over-age systems and estimates for lead-based paint abatement, handicapped access, and net energy conservation (although the repair standards and specific systems may differ). Both exclude the cost of asbestos removal, the cost of demolition, and the cost of major redesign and reconfiguration.

Exhibit 2-3 shows that a standardized comparison of the total national unfunded needs is marked by a steep decline from 1990 to 1998—a decline in 1998 dollars from $33.26 billion to $21.6 billion, or 35 percent. At the per-unit level the decline in total national unfunded needs is 29 percent. It is important to note that the decline in unfunded needs may not be uniform across housing authorities. In fact, it is likely that some housing authorities may have experienced an increase in unfunded needs. Part of the difference between 1990 and 1998 unfunded needs is accounted for by the different number and composition of units in the 1990 and 1998 studies. The 1990 study estimates applied to 1.312 million public housing units, whereas the 1998 study estimates applied to 1.206 million units. The 1998 study excluded units with past and approved demolition and with approved HOPE VI major revitalization, both of which would have had high per-unit needs. The reduction of 106,000 units from the 1990 to 1998 studies is only 8.1 percent, versus a 29 percent reduction in existing need per unit. Even if the units dropped from 1990 to 1998 are assumed to have twice the existing need per unit as the units that remain, the reduction of units would still account for less than half of the overall decline in need.

Exhibit 2-3
Comparing the 1990 and 1998 Estimates of Unfunded Need
(in 1998 dollars)

	1990 Adjusted	1998 Adjusted
Number of units	1.312 million	1.206 million
Repair, add, upgrade, over-age	$31.53 billion	$19.98 billion
LBP abatement	$.48 billion	$.98 billion
Disabled access	$.40 billion	$.32 billion
Energy conservation	$.85 billion	$.32 billion
Existing unfunded need: Aggregate total	$33.26 billion	$21.60 billion
Existing unfunded need: per unit	$25,330	$17,910
Existing need: aggregate total	N/A	$24.6 billion

Notes: The 1990 data come from Table 2.1 of the 1990 HUD *Report to Congress on Alternative Methods for Funding Public Housing Modernization.* The 1998 data come from Exhibit 2-2 above.

Comparing 1990 and 1998 Estimates of Accrual Needs

In contrast to estimates of existing needs that resulted primarily from direct inspections, the estimates of accrual needs in both 1990 and 1998 were derived from system lifetime models that were applied to data gathered during the inspection. Both accrual models shared many assumptions. They were both developed using expert experience. Both were physical system models that emphasized predictable aging of existing systems. In their assumed lifetimes of systems, both adjusted for family and elderly developments. The 1998 model also adjusted somewhat for household density of the unit and development. Neither model adjusted for neighborhood or climatic differences across properties. As with the modernization needs comparisons, adjustments were made to make the numbers comparable. The 1990 accrual data are inflated to 1998 dollars using a 27 percent CPI cost. Soft costs are reflected by adding another 5.4 percent, as was done for existing modernization needs. To account for the impact of deferred modernization in the 1990 model (which was not included in the 1998 model), 1990 costs were reduced by 8.7 percent.[7] To account for the fact that the 1990 system included over-age systems in accrual the 1990 numbers were reduced by .332 billion a year (6.64 billion divided by 20). The 1998 data come from Exhibit 2-2 above.

7 The 1998 model did not account for the impact of deferred modernization on accrual. We believe the magnitude would be smaller than in 1990 because deferred needs that would contribute to accrual relative to recent appropriations were less in 1998 than in 1990.

As shown in Exhibit 2-4, while unfunded existing modernization needs declined markedly from 1990 to 1998, the twenty-year average accrual projected in 1998 is slightly more than the comparable twenty-year accrual average for 1990. In per-unit terms the 1998 value is about 10 percent higher than the 1990 value. The moderate increase in the per-unit accrual estimate may be due to the overall change in average system lifetimes, to the lessened need for immediate repairs in the stock in 1998, and to the greater recognition of household density in the 1998 accrual model.

Exhibit 2-4
Comparing the 1990 and 1998 Estimates of Accrual Need
(1998 dollars)

	1990 Adjusted)	1998 Adjusted
Number of units	1.312 million	1.206 million
Total accrual need per year, average for 20 years	$2.01 billion	$2.03 billion
Per unit accrual need per year, average for 20 years	$1,530	$1,680

Note: The 1990 accrual data come from Table 2.2 of the 1990 HUD *Report to Congress on Alternative Methods for Funding Public Housing Modernization.* The 1998 numbers come from Exhibit 2-2 above.

Chapter Three:
Modeling Public Housing Capital Needs

This chapter presents the results of using rigorous statistical techniques, together with the sample of up-to-date physical needs assessment data, to model the nation's public housing capital needs at the development and public housing authority (PHA) levels. The model can form the basis of the new Capital Fund's revised needs-based formula for allocating HUD capital funds to each housing authority across the country. The chapter will proceed as follows. First, we discuss the rationale and methodology for modeling capital needs. The following section describes the model HUD used for predicting capital needs for the Comprehensive Grant Program (CGP). We then present the development process of the revised model in detail, along with the strengths and limitations of the various alternative models. The chapter concludes with a discussion of the new model and its policy ramifications in terms of funding distribution.

Rationale and Methodology for Modeling Capital Needs

A key purpose of the Formula Capital Study was to assist HUD in revising the formulas for allocating capital funds to public housing authorities, replacing both CGP and CIAP. This requires estimating capital needs for the public housing stock. Collecting physical needs data for every single development in the public housing stock would be prohibitively costly and time-consuming. Instead, this study adopted the approach of scientific sampling that only required the collection of physical needs information on a nationally representative sample of developments. This sample of 684 developments from 219 housing authorities nationwide, as discussed earlier and in Appendix A, can be used to generate aggregate capital needs estimates (referred to as weighted-sample estimates, or direct estimates) for the inspection universe and for groups of housing authorities. However, the Capital Fund formula is designed to allocate funding to ***individual*** housing authorities, rather than groups of housing authorities. In other words, the formation and revision of the formula requires capital needs information for every single housing authority (rather than groups of housing authorities) across the nation. This inevitably calls for an indirect method to estimate the modernization needs of each development and housing authority for which we do not have direct inspection-based measures.

There are two acceptable approaches to generalizing estimates from a representative sample to member units of the universe outside of the sample—a cell-mean approach or a multiple regression model. The first approach is that, starting by categorizing the housing developments in the inspection sample into meaningful groupings (cells), we can relate capital needs estimates to the characteristics that define each group. For public housing developments and housing authorities that were not included in the inspection sample, this approach can be used if we assume that these developments have the same level of capital

needs as the sample developments with similar characteristics. In practice, the average value of the per-unit direct need estimates of each group could be used. We call this the ***cell-mean*** approach. One obvious and natural choice for a grouping criterion is housing authority size—that is, housing authorities with less than 250 units, housing authorities with 250 to 1,249 units, housing authorities with 1,250 to 6,600 units, and housing authorities with more than 6,600 units. Based on the estimates by size category presented in Chapter Two, this would yield the following basis for estimating capital needs:

- For housing authorities with less than 250 units, inspection-based existing modernization needs are $13,868 per unit and accrual needs are $1,821 per unit per year.

- For housing authorities with 250 to 1,249 units, inspection-based existing modernization needs are $17,631 per unit and accrual needs are $1,640 per unit per year.

- For housing authorities with 1,250 to 6,600 units, inspection-based existing modernization needs are $18,875 per unit and accrual needs are $1,645 per unit per year.

- For housing authorities with more than 6,600 units (excluding New York City, Chicago, and Puerto Rico), inspection-based existing modernization needs are $21,462 per unit and accrual needs are $1,554 per unit per year.

As an illustrative example, the Fall River Housing Authority in Massachusetts has 1,803 public housing units under its jurisdiction and it thus falls in the third PHA-size category. No Fall River developments were selected into the inspection sample, therefore up-to-date direct measures of capital need are not readily available. The total estimated inspection-based existing modernization and accrual needs for the housing authority, according to the cell-mean approach, are $34,031,625 ($18,875 × 1,803) and $2,965,935 per year (i.e., $1,645 × 1,803), respectively.

The obvious advantage of the cell-mean approach for modeling capital needs and funds allocation is its administrative simplicity. No additional data collection is required. This approach, however, inevitably ignores the heterogeneity (besides housing authority size) among housing authorities in terms of development attributes, and in regional and neighborhood characteristics. This could lead to misallocation of funding.

The second method for indirect needs estimate involves the use of ***multiple regression techniques***. It can be viewed as a multivariate extension of the cell-mean approach, and can lead to a more equitable and reliable way of allocating capital funds to local housing authorities. It is preferable to the cell-mean approach because it estimates capital needs according to an array of housing authority and development factors, rather than just PHA size. Using the sample of standardized inspection data and a host of secondary databases containing background information on the developments, multiple regression

techniques will relate capital needs estimates to a complex array of development, housing authority, and location characteristics. It is a statistical technique that allows the outcome measure (also called the dependent variable) to be expressed as a linear combination of predictors (also called covariates, independent or explanatory variables) multiplied by their respective regression coefficients (also called regression weights).[1]

Current Need Estimation Model Used by HUD

The current CGP formula was established on the foundation of multiple regression models built by HUD researchers in the early 1990s, using a set of inspection data collected by Abt Associates Inc. in 1985.[2] The funding allocation formula for CGP depends on regression equations that predict capital needs for every development in the country in housing authorities with over 250 units, based on an array of development, housing authority, and neighborhood characteristics. Separate models were built to predict "backlog" and "accrual." These concepts are ***similar*** to the current study's concepts of inspection-based estimates of existing modernization needs and accrual needs, although some variations exist.[3]

For the "backlog" model of the current CGP formula, the need predictors were:

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1 For technical details, please see, for example, William H. Greene, *Econometric Analysis*, 3rd Edition (Upper Saddle River, NJ: Prentice-Hall, 1997).

2 *Study of Modernization Needs of the Public and Indian Housing Stock - National, Regional and Field Office Estimates: Backlog of Modernization Needs* (Abt Associates Inc., Cambridge, MA: 1988). *Future Accrual of Capital Repair and Replacement Needs of Public Housing* (Fairfax, VA: ICF Inc., 1989). *Report to Congress on Alternative Methods for Funding Public Housing Modernization* (Washington, DC: US Department of Housing and Urban Development, 1990).

3 For the backlog measure used in the current CGP formula, HUD relied on data from the 1985 Abt Associates Inc. Modernization Needs Study in HUD's 1990 Report to Congress. Although the inspection and costing approaches were similar to those used in the Formula Capital Study, there are some differences in the definitions of backlog versus inspection-based estimates of existing modernization needs. The CGP formula "backlog" estimate included immediate repair needs, items that had to be added to meet local codes or HUD requirements, and some property-specific additions needed or desirable for long-term viability. The national total "backlog" estimate in the 1988 report also included lead-based paint testing and abatement and renovation and redesign for wheelchair access, but these were not included in the formula modeling. As noted in Chapter Two, the current existing modernization needs measure places more emphasis on upgrades and assumes replacement of over-age systems. The CGP accrual model is based on ICF's accrual estimates, which are similar in concept to the current definitions but rely on the inspection items included in the previous study, and were estimated using a different modeling approach (survival modeling).

- Average number of bedrooms in the units in a development
- Proportion of units in a development available for occupancy by very large families
- Extent to which units for families are in high-rise elevator developments
- Building age (defined by the Date of Full Availability)
- For large housing authorities, the total number of units with 2 or more bedrooms (with 5,000 deducted from that number and the resulting value bounded by zero and 15,000)
- R.S. Means location cost factor
- Severe population decline in the city (defined as population loss from 1970 to 1980 in excess of 12 percent for the city; resulting value is set to zero for elderly projects or when population loss is less than 12 percent).

For the "accrual" model of the current CGP formula, the need predictors were:

- Average number of bedrooms in the units in a development
- Proportion of units in a development available for occupancy by very large families
- Building age (defined by the Date of Full Availability)
- Low-density factor: the extent to which the buildings in a development average fewer than 5 units
- R.S. Means location cost factor
- For housing authorities that own or operate 250 or more units, the total number of units.

Using these models, backlog and accrual needs were estimated for all developments in CGP-eligible housing authorities. Estimates were calibrated to 1990 dollars. Housing authority-level estimates were then obtained by summing across all developments in each PHA. To create an estimate of net unfunded backlog and accrual, a portion of the CIAP funds allocated to each PHA in FY1984-1991 and a portion of MROP funds from FY88 to FY93 were deducted from the housing authority-level estimates of backlog that had been calibrated to reflect 1990 estimates of need. The total national backlog and accrual were estimated by summing the estimates across each housing authority. Then, each housing authority was assigned “shares” of total backlog and total accrual needs, which were their percentages of the total national estimates. The actual allocation share was based on a 50 percent weight for backlog and a 50 percent weight for accrual. Each year, the capital funds HUD allocates to any given housing authority eligible for CGP equal that housing authority’s share multiplied by the total CGP appropriation, with adjustments later made for status as a moderately troubled housing authority.

Development Process of the Revised Models for the Model-Based Estimation of Capital Needs

This section presents the process Abt Associates Inc. used in deriving and testing the revised capital

needs estimation models. The quantities we modeled are the per-unit inspection-based existing modernization needs and the accrual needs of public housing developments as defined in Chapter Two. Specifically, in this step we used the needs estimates before they were adjusted for local cost variations using the R.S. Means adjustment factors. Predicted estimates generated from the models were then multiplied by the R.S. Means cost adjustment factors at the final stage. Regression models were built using inspection-based data from the representative sample of 684 developments in the Formula Capital Study, together with a wealth of data from housing authorities, HUD's Integrated Business System (IBS), and the 1998 "Picture of Subsidized Households" database available on the HUD User web page. Please refer to Appendix B for the documentation and data quality of the various data sources.

In developing the models, inspection data obtained from the New York City, Chicago, and Puerto Rico housing authorities were excluded from the regression estimation.[4] This decision was motivated by two factors. First, cross-tabulations of the inspection data revealed that capital needs as well as development characteristics in those very large housing authorities were atypical of the whole public housing stock. Inclusion of those properties in the modeling process would considerably lower the statistical goodness-of-fit of the final models and could potentially distort the regression equations for the whole stock. Second, the sampling strategy of the study ensured that these housing authorities had a sufficient number and variety of inspected properties to sustain precise sample-based estimates of their capital needs. In other words, direct estimates from the inspection sample for these housing authorities may be used to determine capital needs.

The remainder of this section is organized as follows. We first discuss the criteria for and process of selecting valid need predictors. The method of measuring goodness-of-fit among the alternative models and specifications is then described. Finally, we examine the final models and present some interpretations.

Selecting Predictor Variables

Our variable selection process was primarily guided by what we expected to influence the level of existing modernization needs and accrual needs in public housing. Previous studies and professional judgement have informed us that, for instance, the average number of bedrooms per unit in a development should have an impact on the capital needs per unit, as it represents the mix of elderly and family units and is associated with the square footage per unit that can require repair. Another important determinant is the development's building age. This represents years of physical wear and possible under-maintenance and should be positively related to capital needs, everything else being equal.

4 Although projects in Puerto Rico were excluded from the model development process, formula shares for Puerto Rico were estimated using the models.

Furthermore, other characteristics of the property such as negative development features observed by the study inspectors, housing authority characteristics, and neighborhood location of the development are also expected to affect capital needs.

Besides plausibility and conventional wisdom, the following are additional criteria for selecting predictor variables:

Statistical significance. The variable must be significantly related to the capital need measures in the regression equation. In technical terms, the estimated regression coefficient of the need predictor must be statistically different from zero at the 90 or 95 percent confidence level.

Non-collinearity. The variable cannot be highly associated with the other predictor variables already in the regression equation.

Net explanatory power. When the variable is added to the regression, it should substantially improve the overall fit of the regression equation. In technical terms, after adding the predictor, the adjusted R-squared statistics of the regression should increase noticeably.

Ease of collection. A measure of the variable is readily available in one of the HUD databases, or it can be easily collected from housing authorities in a standardized format. Otherwise, administrative costs of collecting the variable for every public housing development in the country could be prohibitively high.

Guided by these criteria, we have experimented with over 30 predictors in the model-building process. Exhibit 3-1 shows an exhaustive list of all the development, housing authority, and neighborhood predictor variables we have tried. Most of them were not selected as the need predictors for the final models because they violated the principle of non-collinearity, and their addition to the regression equations brought insignificant net-explanatory power. For example, we found that the need predictor that measures the proportion of single-parent households residing in the property is closely associated both with the average number of bedrooms and the variable that indicates whether the development is family occupancy type. Therefore, the indicator for single-parent households should not be used if we want to keep either of the latter two variables in the model. It should be noted that the exclusion of this predictor in the final models does not imply that the proportion of single-parent households among tenants has no bearing on a development's capital needs. Rather, it suggests that predictors such as family occupancy type and average number of bedrooms may already

Exhibit 3-1: Property, Housing Authority, and Neighborhood Characteristics Variables Used in the Model Development Process

Variables:	Data Source:

Property Characteristics:	
Average Number of Bedrooms (BRs)[a]	Inspection Data
Average Sq. Ft. Per Unit	Inspection Data
Total Development Size (Units)	Inspection Data
Construction Building Age (defined by construction completion date)	Inspection Data
Building Age (defined by Date of Full Availability)	HUD IBS File
High-rise	Inspection Data
High-rise Family (i.e., both High-rise and family)	Inspection Data
Townhouse	Inspection Data
Single-Family	Inspection Data
Housing Authority Size (Units)	PIH Master File
Family[b]	Inspection Data
Large Family (i.e., avg. BR > 2.5)	Inspection Data
Low-Density Factor (i.e., max [(5-units/bldg, 0)])	Inspection Data
Property Quality Descriptors:	
Number of Negative Development Features	Inspection Data
Total Number of Negative Housing Quality Standards (HQS) Scores	Inspection Data
Evidence of Rodents	Inspection Data
Evidence of Cracks or Leaks	Inspection Data
Poor Quality Building Maintenance	Inspection Data
Poor Quality Grounds Maintenance	Inspection Data
Modernization Experience and Plans:	
Percent Units Receiving No Major Mod Funds Last 5 Yrs	Inspection Data
Percent Units Receiving No Major Mod Funds Last 10 Yrs	Inspection Data
Housing Authority Estimate of Development's Hard Costs Per Unit	Data from Housing Authority
Housing Authority Estimate of housing authority's Hard Costs Per Unit	Data from Housing Authority
Per-Unit Mod Funds in 1993-1996	Data from Housing Authority
Per-Unit Mod Funds in Next 4 Years	Data from Housing Authority
Development Tenant Demographics:	
Percent Households with Very Low Income	Picture of Subsidized Households
Percent Single-Parent Households	Picture of Subsidized Households
Average Household Size	Picture of Subsidized Households
Percent Elderly/Disabled	Picture of Subsidized Households
R.S. Means Adjustment Factor:	
R.S. Means Location Cost Adjustment Factor	R.S. Means
PHMAP Indicators:	
PHMAP Grade for Modernization	PHMAP
Overall PHMAP Grade	PHMAP
Percent Occupied Units	Picture of Subsidized Households
Housing Authority-Level Adjusted Vacancy Rate	PHMAP
Neighborhood Characteristics:	
Poverty Rate in Census Tract	Picture of Subsidized Households
Overall Neighborhood Quality Fair or Poor	Inspection Data
Census Region	U.S. Census File
Metropolitan Location	U.S. Census File
Central City Location	U.S. Census File

a Studio units defined as 0 bedrooms. The current CGP formula also counts studio units as 0 bedrooms. The FY99 CIAP formula counts studio units as 1 bedroom.

b Developments with an average bedroom size greater than 1.5 or greater than 1.2 with 100 or more 2+ bedroom units.

capture the impact of such a tenant population on the property's capital needs level. The same line of reasoning can be applied to explain the exclusion of other need predictors in the final models. We arrived at two final sets of alternative models—four for predicting pre-R.S. Means-adjusted model-based estimates of existing modernization needs, and four for predicting pre-R.S. Means-adjusted model-based estimates of accrual needs. (In other words, the models predict need prior to R.S. Means adjustments. However, for all cost estimates presented in this report, we applied the adjustment factors.) Exhibit 3-2 and Exhibit 3-3 present the list of predictors we used in each of the models. Several similarities and differences among the models deserve comment before we proceed to the discussion of the goodness-of-fit measures:

- First, Model 1-a and Model 1 use essentially the same set of need predictors for model-based estimates of existing modernization needs. The only difference between them is that the former consists of two separate regression equations—one estimated for developments in housing authorities with less than 250 units and another one estimated for developments in housing authorities with 250 or more units. Cross-tabulations of the inspection data have indicated that the two groups of properties have noticeably different levels of per-unit capital needs. This modeling strategy allows the regression equations to further capture the heterogeneity among the developments and arrive at more precise indirect need estimates. The same is true for Model 2-a versus Model 2. For accrual needs, Models 3-a and 4-a are both different from Models 3 and 4 in the same manner, that is, using separate models for properties in housing authorities with above and below 250 units, respectively.

- Second, for model-based estimates of existing modernization needs, Models 2 and 2-a are augmented from Models 1 and 1-a by adding a set of need predictors that measure housing authority characteristics and other physical attributes of the property. (For model-based estimates of accrual needs, the same is true for Models 4 and 4-a versus Models 3 and 3-a.) These measures are not readily available for public housing developments outside of the inspection sample and the administrative cost to collect those data for the whole stock may be burdensome.

Goodness-of-fit Measures of the Alternative Models

Several statistics and methods are widely used by the research community when choosing the preferable specification among alternative sets of regression models.[5] They all center on the

5 Sanford Weisberg, *Applied Linear Regression*, 2nd Edition (New York: John Wiley & Sons, 1985); Russell Davidson and James MacKinnon, *Estimation and Inference in Econometrics* (New York: Oxford University Press, 1993).

Exhibit 3-2: Variables Used in Alternative Models of Inspection-Based Existing Modernization Needs

	Model 1	Model 1-a	Model 2	Model 2-a
Average Number of Bedrooms (per unit)	✓	✓	✓	✓
Total Number of Units at the Development	✓	✓	✓	✓
Building Age is More than 20 Years (Yes/No)	✓	✓	✓	✓
Housing Authority with Less Than 250 Units (Yes/No)	✓	Two separate models: housing authorities < 250 units; housing authorities ≥ 250 units.	✓	Two separate models: housing authorities < 250 units; housing authorities ≥ 250 units.
R.S. Means Location Adjustment Factor	✓	✓	✓	✓
Census Regions (Northeast, South, West, Midwest)	✓	✓	✓	✓
Non-Metropolitan Location (Yes/No)	✓	✓	✓	✓
Number of Negative Development Features			✓	✓
Total Negative HQS Score			✓	✓
Poor Quality Building Maintenance (Yes/No)			✓	✓
Percent Units with No Major Modernization Funds in Last 10 Years			✓	✓
Per-Unit Modernization Funding in 1993-1996			✓	✓
R-Squared Statistics				
Weighted	0.16	0.17[a]	0.33	0.33[a]
Housing Authorities < 250 units	NA	0.20	NA	0.38
Housing Authorities ≥ 250 units	NA	0.16	NA	0.32

a Weighted average of estimates from models for housing authorities with less than 250 units and housing authorities with 250 or more units.

Exhibit 3-3: Variables Used in Alternative Models of Inspection-based Accrual Needs

	Model 3	Model 3-a	Model 4	Model 4-a
Average Number of Bedrooms (per unit)	✓	✓	✓	✓
Low-Density Factor	✓	✓	✓	✓
Building Age	✓	✓	✓	✓
Housing Authority with Less Than 250 Units (Yes/No)	✓	Two separate models: housing authorities < 250 units; housing authorities ≥ 250 units.	✓	Two separate models: housing authorities < 250 units; housing authorities ≥ 250 units.
R.S. Means Location Adjustment Factor	✓	✓	✓	✓
Census Regions (Northeast, South, West, Midwest)	✓	✓	✓	✓
Non-Metropolitan Location (Yes/No)	✓	✓	✓	✓
Family Occupancy Type (Yes/No)	✓	✓	✓	✓
Housing Authority with More Than 6,600 Units (Yes/No)	✓	✓	✓	✓
Percent of Units with No Major Modernization Funds in last 10 Years			✓	✓
Percent of Units with No Major Modernization Funds in last 5-10 Years			✓	✓
Per-Unit Modernization Funding in 1993-1996			✓	✓
Housing Authority-level Adjusted Vacancy Rate			✓	✓
R-Squared Statistics				
Weighted	0.46	0.45[a]	0.44	0.44[a]
Housing Authorities < 250 units	NA	0.45	NA	0.44

Housing Authorities ≥ 250 units	NA	0.45	NA	0.44

a Weighted average of estimates from models for housing authorities with less than 250 units and housing authorities with 250 or more units.

concept of goodness-of-fit of the regression model. In layman's terms, they measure how well the model fits the sample of observations. One often-used measure is the ***R-squared statistic***—it indicates, in proportion, how much the variance in the dependent variable can be explained by the set of predictors in a regression equation.[6] Applied researchers in the modeling field have suggested that regression models with an R-squared of around 0.2 is already noteworthy; an R-squared of 0.5 is considered to be relatively high.[7] The bottom of Exhibit 3-2 and Exhibit 3-3 reported the R-squared statistics of the alternative models. For instance, for existing modernization needs, Model 2 explains approximately 33 percent of the variation of the existing modernization needs in the inspection sample while Model 2-a yields essentially as good a fit (32 percent in R-squared statistic) for small housing authorities and a better fit (38 percent in R-squared statistic) for large housing authorities. Therefore, guided by the R-squared statistics alone, we found that Model 2-a seems to be the preferable choice among the models for predicting per-unit existing modernization needs, and Model 3 provides the best fit for per-unit accrual needs.

However, the merit of using the R-squared statistic as a model selection tool has sometimes been criticized in the research literature.[8] First, and most importantly, R-squared statistics of a model can shift substantially with the exclusion or inclusion of a few influential observations (that is, observations with rather extreme values in the dependent or independent variables) in the sample. This is called the "outlier effect" in the statistics literature. In simple terms, R-squared statistics may not capture the overall goodness-of-fit of a model. Comparing R-squared statistics alone thus may not lead to the best model specification if there are "outlier" observations in the sample. In addition, other researchers have shown that the value of R-squared statistics may be sensitive to whether a constant term is included in the regression equation.

Another way to assess the goodness-of-fit of alternative regression models that may work better for the current situation is through ***model prediction***. The procedures and reasoning of the model prediction exercise are the following. The 568[9] sample properties we used in the regression models are first divided into sixteen groups according to four housing authority-size categories (less than 250 units, 250

6 To be precise, we reported ***adjusted R-squared*** statistics in the text. Compared to the simple R-squared, adjusted R-squared is a more reliable statistic, since it checks whether the contribution of a new predictor to the overall fit of the regression model will be offset by the loss in the degrees of freedom (defined as the number of observations minus the number of variables).

7 William H. Greene, *Econometric Analysis*, 3rd Edition (Upper Saddle River, NJ: Prentice-Hall, 1997).

8 For details, see Robert S. Pindyck and Daniel L. Rubinfeld, *Econometric Models and Economic Forecasts*, 4th Edition (New York: McGraw-Hill, Inc., 1997); William H. Greene, *Econometric Analysis*, 3rd Edition (Upper Saddle River, NJ: Prentice-Hall, 1997).

9 Developments from the New York City, Chicago, and Puerto Rico housing authorities were excluded from the prediction exercise since they were not included in developing the regression models.

to 1,249 units, 1,250 to 6,600 units, and more than 6,600 units excluding New York City, Chicago, and Puerto Rico) and four census
regions (Northeast, South, West, and Midwest). Next, for developments in each group, we compute the following quantities:

- ***Direct estimates.*** They are calculated by multiplying the inspection-based need estimates of each individual sample development by the corresponding sample weight. Development-level estimates are then aggregated to group totals.

- ***Cell-mean predicted estimates***. As mentioned earlier in this chapter, the cell-mean approach for need estimates is based on housing authority size alone. In other words, the method assumes that all developments in the same housing authority-size category have the same level of per-unit capital needs (i.e., cell means). There are four size categories (cells), namely less than 250 units, 250 to 1,249 units, 1,250 to 6,600 units and more than 6,600 units, and each category is associated with a single level of per-unit existing modernization need and per-unit accrual need. As an illustrative example, for housing authorities with less than 250 units, the method considers the inspection-based existing modernization needs to be $13,868 per unit for all developments, regardless of regional locations. Therefore, to calculate the total estimate for housing authorities with less than 250 units in the Northeast region, we multiply $13,868 by the actual number of units of small-size housing authorities in the Northeast region (as measured by the sum of the sample weights of those developments).

- ***Model-based predicted estimates***. For each sample development, this is computed by entering the values of the relevant predictor variables multiplied by the corresponding coefficients in each of the regression models to estimate development-level needs. The model-based development-level estimates are then multiplied by the R.S. Means adjustment factor to account for local cost variations, weighted by the number of units they represent (using sample weights) and aggregated to group totals.

Exhibit 3-4 and Exhibit 3-5 present these estimates and their comparison. The objective of this exercise is to compare the cell-mean estimates and model-based estimates to the direct estimates grouped at the housing authority-size and region levels—the "best" model/approach should be able to generate reliable and precise need estimates that are very close to the direct estimates grouped at those levels. We believe, for the following reasons, this is a more suitable testing procedure than the R-squared statistics for selecting alternative models in this study:

- The R-squared statistic, as a model selection tool, only measures alternative models' goodness-of-fit at the housing development level. However, because the

Exhibit 3-4: Goodness-of-fit Comparison of Alternative Models: Inspection-Based Existing Modernization Needs[a] (In Millions of Dollars)

	Number of sample properties	Direct need estimate	Prediction									
			Cell-mean approach	% Diff.	Model 1	% Diff.	Model 1-a	% Diff.	Model 2	% Diff.	Model 2-a	% Diff.
Housing authority size1 (<250 units)	126	$2,739	$2,739	n.a.	$3,175	15.9	$2,739	0.0	$2,938	7.3	$2,808	2.5
Housing authority size2 (250-1,249 units)	187	$6,036	$6,036	n.a.	$5,869	-2.8	$6,148	1.9	$5,939	-1.6	$5,937	-1.6
Housing authority size3 (1,250-6,600 units)	177	$5,500	$5,500	n.a.	$5,248	-4.6	$5,377	-2.2	$5,540	0.7	$5,627	2.3
Housing authority size4 (6,600+ units)	78	$2,605	$2,605	n.a.	$2,589	-0.6	$2,616	0.4	$2,643	1.5	$2,711	4.1
Average absolute % difference				n.a.		6.0		1.1		2.8		2.6
Average % difference				n.a.		2.0		0.0		2.0		1.8
Housing authority size1-Northeast	12	$199	$359	80.3	$358	79.6	$185	-7.0	$293	47.0	$170	-14.8
Housing authority size1-South	72	$1,747	$1,458	-16.5	$1,772	1.4	$1,761	0.8	$1,698	-2.8	$1,826	4.5
Housing authority size1-West	18	$342	$358	4.8	$427	25.1	$345	1.1	$369	8.0	$361	5.7
Housing authority size1-Midwest	24	$452	$564	24.8	$617	36.7	$447	-1.0	$578	28.0	$451	-0.2
Housing authority size2-Northeast	49	$1,530	$1,591	4.0	$1,408	-8.0	$1,501	-1.9	$1,392	-9.0	$1,434	-6.3
Housing authority size2-South	87	$2,600	$2,763	6.3	$2,764	6.3	$2,814	8.2	$2,778	6.8	$2,719	4.6
Housing authority size2-West	16	$664	$553	-16.6	$588	-11.3	$622	-6.3	$602	-9.3	$576	-13.2
Housing authority size2-Midwest	35	$1,242	$1,129	-9.1	$1,108	-10.8	$1,210	-2.6	$1,167	-6.0	$1,208	-2.7
Housing authority size3-Northeast	39	$1,035	$1,206	16.5	$1,165	12.6	$1,223	18.2	$1,186	14.6	$1,224	18.3
Housing authority size3-South	78	$2,613	$2,414	-7.6	$2,362	-9.6	$2,333	-10.7	$2,511	-3.9	$2,447	-6.4
Housing authority size3-West	25	$744	$750	0.7	$678	-9.0	$713	-4.2	$769	3.3	$787	5.7
Housing authority size3-Midwest	35	$1,107	$1,130	2.1	$1,043	-5.8	$1,108	0.1	$1,074	-3.0	$1,170	5.7
Housing authority size4-Northeast	27	$1,256	$997	-20.6	$1,055	-16.0	$1,080	-14.0	$1,140	-9.2	$1,185	-5.7
Housing authority size4-South	33	$838	$1,043	24.5	$959	14.5	$940	12.2	$943	12.6	$931	11.1
Housing authority size4-West	7	$199	$213	6.9	$253	27.0	$260	30.6	$210	5.5	$221	11.0
Housing authority size4-Midwest	11	$313	$352	12.6	$322	3.0	$337	7.6	$350	12.0	$375	19.7
Average absolute % difference				15.9		17.3		7.9		11.3		8.5
Average % difference				0.4		0.5		0.1		0.4		0.1
R-squared statistics			n.a.		0.16		0.17[b]		0.33		0.33[b]	

Notes:

Percent difference (% diff.) = [(model-based (or cell-mean) estimate - direct need estimate)/direct need estimate] × 100%.

a Prediction exercise excludes developments of New York City, Chicago, and Puerto Rico housing authorities in the inspection sample.

b Weighted average of estimates from models for housing authorities with less than 250 units and housing authorities with 250 or more units.

Exhibit 3-5: Goodness-of-fit Comparison of Alternative Models: Inspection-Based Accrual Needs[a] (In Millions of Dollars)

	Number of sample properties	Direct need estimate	Prediction									
			Cell-mean approach	% Diff.	Model 3	% Diff.	Model 3-a	% Diff.	Model 4	% Diff.	Model 4-a	% Diff.
Housing authority size1 (<250 units)	126	$360	$360	n.a.	$339	-5.7	$360	0.1	$337	-6.3	$360	0.1
Housing authority size2 (250-1,249 units)	187	$561	$561	n.a.	$584	4.0	$569	1.3	$584	4.1	$565	0.7
Housing authority size3 (1,250-6,600 units)	177	$479	$479	n.a.	$477	-0.5	$472	-1.5	$479	-0.1	$478	-0.4
Housing authority size4 (6,600+ units)	78	$189	$189	n.a.	$189	0.1	$189	0.1	$188	-0.3	$188	-0.3
Average absolute % difference				n.a.		2.6		0.7		2.7		0.4
Average % difference				n.a.		-0.5		0.0		-0.6		0.0
Housing authority size1-Northeast	12	$47	$47	1.3	$41	-12.9	$46	-0.8	$40	-14.7	$45	-3.3
Housing authority size1-South	72	$182	$192	5.2	$178	-2.3	$182	-0.3	$176	-3.4	$181	-0.4
Housing authority size1-West	18	$64	$47	-26.3	$53	-16.6	$64	0.9	$54	-15.7	$66	3.5
Housing authority size1-Midwest	24	$67	$74	10.0	$68	0.4	$68	0.4	$68	0.8	$68	0.3
Housing authority size2-Northeast	49	$138	$148	7.2	$144	4.4	$140	1.3	$142	2.7	$137	-0.7
Housing authority size2-South	87	$250	$257	2.6	$262	4.6	$257	2.6	$262	4.7	$256	2.0
Housing authority size2-West	16	$63	$51	-17.8	$67	6.3	$62	-1.7	$69	9.5	$63	0.7
Housing authority size2-Midwest	35	$110	$105	-4.9	$111	0.9	$110	-0.4	$112	1.4	$110	-0.8
Housing authority size3-Northeast	39	$107	$105	-2.1	$107	-0.6	$106	-1.7	$109	1.3	$108	0.7
Housing authority size3-South	78	$208	$210	1.0	$200	-3.9	$201	-3.6	$200	-4.0	$201	-3.5
Housing authority size3-West	25	$66	$65	-1.4	$70	4.9	$64	-3.2	$70	5.6	$65	-1.7
Housing authority size3-Midwest	35	$97	$98	1.1	$100	3.0	$102	4.4	$100	2.6	$103	5.7
Housing authority size4-Northeast	27	$77	$72	-5.8	$77	0.6	$77	0.2	$76	-1.3	$76	-1.0
Housing authority size4-South	33	$68	$76	11.0	$67	-0.9	$68	0.3	$68	-0.1	$69	1.2
Housing authority size4-West	7	$14	$15	7.0	$18	27.9	$17	21.0	$18	27.1	$17	15.2
Housing authority size4-Midwest	11	$30	$26	-13.6	$26	-11.8	$26	-11.0	$26	-11.1	$27	-8.9
Average absolute % difference				7.4		6.4		3.4		6.6		3.5
Average % difference				-0.1		0.0		0.0		0.0		0.0
R-squared statistics			n.a.		0.46		0.45[b]		0.44		0.44[t]	

Notes:
Percent difference (% diff.) = [(model-based (or cell-mean) estimate - direct need estimate)/direct need estimate] × 100%.

a Prediction exercise excludes developments of New York City, Chicago, and Puerto Rico housing authorities in the inspection sample.

b Weighted average of estimates from models for housing authorities with less than 250 units and housing authorities with 250 or more units.

Capital Fund formula is designed to distribute funds to housing authorities (rather than housing developments), our ultimate concern should be whether the "best" model can perform well at the housing authority and housing authority size-region level. In other words, whereas it is still pivotal that we control for heterogeneous factors at the housing development level in the regression models, accuracy of the model's needs prediction at the housing authority level is more important (relative to accuracy at the housing development level, as measured by the R-squared statistics).

- It is difficult to fully control for all the differences among housing developments in the regression models. These unobserved heterogeneous factors as well as "outlier" observations at the housing development level can easily distort the R-squared statistics. Comparing R-squared statistics alone therefore may not lead to the "best" model. However, when the model-based estimates are grouped into housing authority-size and region levels, variations in the predicted needs caused by uncontrolled heterogeneities and outliers among housing developments are likely to cancel or balance out each other. This gives the alternative models' overall goodness-of-fit a more robust assessment.[10]

When the cell-mean estimates and the model-based estimates are compared to the direct estimates, we compute the following statistics[11] to indicate a model's predictive power:

- Difference (percent) for each of the four housing authority size categories
- Difference (percent) for each of the sixteen housing authority-region categories
- Average difference (percent) for the four housing authority size categories
- Average difference (percent) for the sixteen housing authority-region categories
- Average absolute-difference (percent) for the four housing authority size categories
- Average absolute-difference (percent) for the sixteen housing authority-region categories

Intuitively, the smaller these statistics are, the greater the predictive power of the model. Judging from this set of statistics in the two exhibits, for both inspection-based existing modernization needs and accrual needs, the model-based methods clearly out-perform the cell-mean approach. Among the models for predicting per-unit existing modernization needs, although Models 2 or 2-a have the highest

10 An alternative remedy is to estimate the existing modernization and accrual needs models at the housing authority level, by aggregating the per-unit capital needs and predictor variables from the inspection sample developments into weighted housing authority-level data. However, compared to our recommended approach of estimating the models at the housing development level, this method has a major disadvantage: it will substantially reduce the total number of observations available to the regression models from a sizable 568 (developments) to a modest 216 (housing authorities).

11 We define percent difference (% diff.) = [(model-based (or cell-mean) estimate – direct need estimate)/direct need estimate] × 100%.

R-squared value, Model 1-a yields predicted (model-based) estimates that are on average much closer to the direct estimates.[12, 13] In absolute values, for instance, the average difference between the predicted and the direct need estimates is only 7.9 percent across the sixteen housing authority size-region categories for Model 1-a. That is the smallest difference among the models presented in Exhibit 3-4. Also, compared to Model 2-a, Model 1-a does not impose administrative burden to collect additional data—for example, the government cost of hiring study inspectors to collect standard information for the "number of negative development features" variable in Model 2-a for the entire stock would be prohibitively expensive. Taking all these model-selection criteria (namely, R-squared, predictive power statistics, and ease of data collection) into consideration, we recommend Model 1-a as the preferable model for predicting per-unit inspection-based existing modernization needs.

For per-unit accrual needs, Exhibit 3-5 indicates that all four models have very similar R-squared statistics. Relative to the other models, Model 3-a has smaller differences when we compare the model-based need estimates to direct estimates. The average absolute value of differences between the model-based estimates and direct estimates is only 3.4 percent across the sixteen housing authority size-regions for Model 3-a. This implies that Model 3-a provides the best "goodness-of-fit" in terms of predictive power. In addition, it also has the virtue that all the necessary variables required in the model are readily available or can be computed from the HUD master universe file for the entire public housing stock. In other words, the model also satisfies the "ease of data collection" principle. We therefore recommend Model 3-a as the model for predicting per-unit accrual needs.

12 Besides the possibilities of "outliers" and uncontrolled heterogeneities mentioned above, this inconsistency can be due to the disparities of capital needs and other housing authority attributes across regions. The overall R-squared statistic of a model can be easily distorted if the model fits the data particularly well (or worse) in a few of the sixteen housing authority size-region categories. Moreover, relative to Model 1-a, the additional set of variables in Model 2-a may not be crucial for predicting capital needs at the housing authority-size and region levels.

13 The single R-squared statistic reported for Model 1-a is calculated as a weighted average of the two R-squared statistics from models for housing authorities with less than 250 units and housing authorities with 250 or more units. The same method was used to calculate the weighted R-squared statistics for Models 2-a, 3-a and 4-a.

Recommended Models for Predicting Capital Needs

The final set of recommended models for estimating inspection-based existing modernization needs and accrual needs are shown in Exhibits D-1 and D-2 of Appendix D, using Models 1-a and 3-a.[14] Exhibit 3-6 presents the basic descriptive statistics for variables used in the regression models from the inspection sample. Overall, the models provide a decent fit to the sample observations—for existing modernization needs, the R-squared statistics are 0.20 and 0.16 for models of developments in housing authorities with less than 250 units and developments in housing authorities with 250 units or more, respectively; for accrual needs, the models for both housing authority-size classes have an R-squared of 0.45. The predictors in the accrual needs models in general explain a larger proportion of variation of the dependent variable than do the models existing modernization needs. Moreover, compared to the model for existing modernization needs, the accrual needs models are associated with more for significant regression coefficients.[15] This is probably due to the fact that the accrual needs measure itself is a "modeled" quantity in the physical needs assessment process. It is thus relatively easy to capture its range of values by a regression equation.

Using separate models for developments in housing authorities above and below 250 units, the final set of predictors for per-unit inspection-based existing modernization needs consists of:

- Average number of bedrooms in the units in a development
- Total number of units in a development
- Whether the development's building age is greater than 20 years
- R.S. Means location cost factor
- Whether the development is located in a non-metropolitan area
- Whether the development is located in the South census region
- Whether the development is located in the West census region
- Whether the development is located in the Midwest census region.

14 The recommended models use exactly the same set of need predictors recommended to HUD for the Negotiated Rule-Making Committee Meetings held in the summer of 1999. The model coefficients reported here, however, made use of a more complete and up-to-date database. Specifically, we have updated the information of one data element (i.e. the non-metropolitan location status of each sample property). This increased the usable sample from 525 to 568 properties. The sample of small PHAs increased from 95 to 126, and the sample of large PHAs from 430 to 442. The models now yield estimates that are more robust. The resulting coefficient estimates are slightly different from those reported to the HUD Negotiated Rule-Making Committee Meeting. But, overall, these differences are essentially negligible and show no material impact in terms of potential funding allocation by housing authority size categories. Some comparisons are shown in Appendix D.

15 Given the sample size limitation, particularly in the group of housing authorities with less than 250 units, it is not unexpected to observe that some of the regression coefficients in the recommended models do not attain statistical significance at the conventional 90- or 95- percent levels.

Exhibit 3-6: Descriptive Statistics of Variables (Weighted) Used in the Recommended Inspection-Based Existing Modernization Need and Accrual Need Models (for Inspection Sample of Properties); Needs not Adjusted by Inter-Area Costs

Developments in Housing Authorities with less than 250 Units				
Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Per-unit Existing Modernization Needs	15523.45	12207.33	42.805	55714.86
Per-unit Average Annual Accrual Needs	1956.647	595.309	723.626	4235.313
Average Number of Bedrooms	1.869	0.725	0.340	3.676
Low-Density Factor	1.909	1.376	0	4
Family Development	0.690	0.464	0	1
Total Units in Development	61.055	39.169	4	170
Building Age	27.674	10.689	4	56
Building Age > 20 Years	0.760	0.429	0	1
R.S. Means Location Adjustment Factor	0.936	0.126	0.713	1.340
Non-metropolitan Location	0.620	0.487	0	1
Census Region:				
Northeast[a]	0.131	0.339	0	1
South	0.532	0.501	0	1
West	0.131	0.338	0	1
Midwest	0.206	0.406	0	1
Number of Observations from Inspection Sample: 126				
Developments in Housing Authorities with 250 or More Units[b]				
Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Per-unit Existing Modernization Needs	18688.25	12709.35	0	63570.88
Per-unit Average Annual Accrual Needs	1628.164	590.074	574.142	4833.754
Average Number of Bedrooms	1.879	0.800	0	3.795
Low-Density Factor	0.843	1.269	0	4.081
Family Development	0.712	0.453	0	1
Total Units in Development	234.003	200.027	6	1136
Building Age	35.341	13.256	4	61
Building Age > 20 Years	0.883	0.322	0	1
PHA with More Than 6600 Units	0.161	0.368	0	1
R.S. Means Location Adjustment Factor	1.015	0.135	0.713	1.287
Non-metropolitan Location	0.153	0.360	0	1
Census Region:				
Northeast[a]	0.266	0.442	0	1
South	0.441	0.497	0	1
West	0.107	0.310	0	1
Midwest	0.186	0.389	0	1
Number of Observations from Inspection Sample: 442 [b]				

a Denotes reference category in regressions.

b Excludes observations in New York City, Chicago and Puerto Rico housing authorities in the inspection sample.

Note: Because needs in this table are not adjusted by inter-area costs, the per-unit existing modernization needs and the per-unit accrual needs are not comparable to those in Exhibit 2-1, where needs are adjusted for inter-area costs.

Using separate models for developments in housing authorities above and below 250 units, the final set of predictors for per-unit accrual needs includes:

- Average number of bedrooms in the units in a development
- Low-density factor: the extent to which the buildings in a development average fewer than 5 units
- Building age of the development
- Whether the development is a family development
- Whether the development is associated with a housing authority that owns or operates more than 6,600 units
- R.S. Means location cost factor
- Whether the development is located in a non-metropolitan area
- Whether the development is located in the South census region
- Whether the development is located in the West census region
- Whether the development is located in the Midwest census region.

Policy Implications of the Revised Models

This section presents the model-based inspection-based needs estimates for the 1999 CGP/CIAP universe of public housing and explores some of the policy implications of the recommended models in terms of HUD capital funds allocation. We first used the latest HUD master universe file (as of June 1999) to generate the model-based capital needs estimates for every public housing development in the 1999 CGP/CIAP universe using the recommended inspection-based existing modernization needs and accrual needs models. All model estimates were multiplied by an R.S. Means adjustment factor to account for local cost variations. Development-level estimates were then aggregated into housing authority-level totals. For the New York City and Chicago housing authorities, the direct estimates were used for the reasons mentioned previously in this chapter. To estimate needs for units in Puerto Rico, we applied the model results for housing authorities with 250 or more units to the characteristics of Puerto Rico's stock. Exhibit 3-7 shows how these total and per-unit needs estimates are distributed across different size housing authorities.

These model-based estimates are related to the direct estimates reported in Exhibit 2-1 of Chapter Two. Several important differences and similarities between the quantities in the two exhibits deserve comment:

- The direct estimates in Exhibit 2-1 are based on the inspection universe and exclude units approved for demolition or HOPE VI, and units in Alaska, Hawaii, Guam, and the U.S. Virgin Islands. However, the model-based estimates presented in Exhibit 3-7 reflect the full

1999 CGP/CIAP universe. The total estimates of capital needs are higher for the full 1999 CGP/CIAP universe because it includes more units. In addition, the distribution of shares of total

- **Exhibit 3-7: National Distribution of Model-Based Capital Need Estimates for the 1999 CGP/CIAP Universe**

Public Housing Authority Size	Total Units[a]	Existing Modernization Needs		Average Annual Accrual Needs	
		Total	Per-Unit	Total	Per-Unit
Less than 250 units	203,687	$2,578,361,860	$12,658	$360,953,187	$1,772
250 to 1,249 units	336,648	$5,728,615,775	$17,017	$555,179,453	$1,649
1,250 to 6,600 units	342,266	$6,327,732,638	$18,488	$571,954,000	$1,671
More than 6,600 units[b]	204,533	$4,718,442,859	$23,069	$319,871,450	$1,564
New York City[c]	160,209	$3,679,503,620	$22,967	$302,163,581	$1,886
Chicago[c]	38,788	$1,041,543,510	$26,852	$53,555,225	$1,381
National Total	1,286,131	$24,074,200,262	$18,718	$2,163,676,896	$1,682

a Unit counts based on the HUD Master Universe file for June 1999.

b Excluding units in New York City and Chicago housing authorities, but including units in Puerto Rico.

c Estimates based on unit counts from the HUD Master Universe file and per-unit need estimates from the inspection sample.

needs estimates is not exactly comparable in the two exhibits because the variations in the two universe counts vary by housing authority size category. However, when we compare the estimates with the direct estimates just for the inspection universe, the total numbers are identical at $22.5 billion for inspection-based existing modernization needs, and $2 billion per year for accrual needs.

- Given the above qualification, the per-unit needs estimates reported in the two exhibits are roughly comparable. While there are some discrepancies, many of the per-unit model-based estimates of need are in close proximity to the direct estimates. For instance, for properties in housing authorities with 250 to 1,249 units, the direct estimates of existing modernization needs in the inspection universe and accrual needs are $17,017 and $1,649 per unit respectively, while the corresponding model-based estimates are $17,017 and $1,624 per unit. For housing authorities with 1,250 to 6,600 units, the per-unit model-based estimates are also very close to the ones from the direct estimates. The discrepancies between the model-based and direct estimates for other housing authority-size categories are probably attributable to the differences in universe counts between the 1999 CGP/CIAP and inspection universes. Overall, the tabulations provide some confirmation regarding the reliability and accuracy of our

recommended models in predicting capital needs that are close to most of the inspection-based estimates.[16]

As mentioned earlier in the chapter, the models can form the basis of a new needs-based formula for allocating HUD capital funds to public housing authorities across the nation. Allocations can take many forms. One obvious choice is to allocate funds in proportion to capital needs—either just existing modernization needs, just accrual needs, or some combination of the two, such as is done under the current Comprehensive Grant Program. Other allocation rules could provide more weight to larger developments, to larger housing authorities, or to developments with higher needs.

To see the possible distributional implications of a new system, we have computed the "shares" (i.e., percentages) of total inspection-based existing modernization needs and total accrual needs for each housing authority size group, based on the model-based estimates of need for the 1999 CGP/CIAP universe reported in Exhibit 3-7. The results are presented in Exhibit 3-8. The allocation shares currently in use and calculated from the CGP and CIAP systems are shown for reference in the exhibit. To allow comparison with the current CGP allocation rule, we also included in the exhibit allocation shares that are based on a 50 percent weight for the existing modernization needs share and a 50 percent weight for the accrual needs share.

Overall, regardless of how the shares for existing modernization needs and accrual needs are combined into the final allocation shares, assuming future allocations are in proportion to the estimates of need, a moderate shift in funds allocation could occur between housing authority size categories. If shares for particular housing authorities vary considerably between the new and current systems, HUD can adopt an approach that implements the changes gradually. One approach could be, for example, for an individual authority to cap the funding reduction going from the current to the revised systems to a certain percent (for instance, 5 or 6 percent) of the housing authority's current allocation. This could temper the adverse effect on individual housing authorities that may experience a substantial shift in relative needs between the current and revised systems.

We now focus our discussion on the share comparison where the allocation shares are calculated as a 50 percent weight for the existing modernization needs share and a 50 percent weight for the accrual need share:

- As expected, both the revised and current shares are in proportion to the total number of units in each housing authority category. For example, the category of

16 Per-unit needs estimates for the New York City and Chicago housing authorities differ from those reported in Exhibit 2-1 because the inspection sample and 1999 CGP/CIAP universes have slightly different distributions of family and elderly developments.

- **Exhibit 3-8: Comparison of Current Funding Shares and Abt Associates Inc. Model-Based Shares for the 1999 CGP/CIAP Universe**

Public Housing Authority Size	Percent of Total Units	50% Mod Share and 50% Accrual Share		100% Mod Share		100% Accrual Share	
		Current Formula	Abt Model	Current Formula	Abt Model	Current Formula	Abt Model
Less than 250 units	16%	13%	14%	7%[b]	11%	14%[b]	17%
250 to 1,249 units	26%	20%	25%	18%	24%	23%	26%
1,250 to 6,600 units	27%	25%	26%	26%	26%	26%	26%
More than 6,600 units[a]	31%	42%	35%	49%	39%	37%	31%
National Total	100%	100%	100%	100%	100%	100%	100%

a Including units in New York City, Chicago, and Puerto Rico housing authorities.

b Under the 1990 formula methods, housing authorities of less than 250 units had about 10.5 percent of total need (based on a 50/50 averaging of backlog and accrual need). In actual allocations, this share was raised in recent years and reached 12.5 percent in FY99, which is closer to their share of need in this study.

housing authorities with more than 6,600 units as a whole contains the largest proportion of units (31 percent). This category has the largest revised share (35 percent) and the largest current share (42 percent).

- In addition, similar to the distribution of the current shares, revised shares are associated with individual housing authority size. On average, larger housing authorities get larger shares of the total funding relative to their share of total units compared with smaller authorities. In other words, fund allocation is not strictly proportional to the housing authority's unit size. For instance, in the revised share distribution, the category of housing authorities with less than 250 units accounts for 16 percent of the stock and its allocation share is only 14 percent; housing authorities with more than 6,600 units as a whole operate 31 percent of the total units and their allocation share is 35 percent. This reflects the fact that most of the large housing authorities have per-unit capital needs above the national average level, while many of the small housing authorities have below-average per-unit needs. (Please refer to estimates presented in Exhibit 2-1 and Exhibit 3-7.)

- For the categories of housing authorities with less than 250 units and with 1,250 to 6,600 units, the revised shares are very close to the ones in the current system.

- Compared to shares in the current system, revised shares will increase for both the small (from 13 percent to 14 percent) and medium (from 20 percent to 25 percent) housing authorities, while allocation to the very large housing authorities decreases (from 42 percent to 35 percent for housing authorities with more than 6,600 units including New York City, Chicago, and Puerto Rico). This implies that the per-unit relative needs, as measured by the definitions of capital needs in this study, of mid-size and small housing authorities have grown relatively more over the decade than the very large housing authorities, although the per-unit needs (in absolute terms) are still substantially higher in large housing authorities.

- Shares for housing authorities with 1,250 to 6,600 units, which account for approximately 27 percent of the total public housing stock, stay roughly the same (increased slightly from 25 percent to 26 percent) between the current and revised formula systems.