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Manual of Build-Out Analysis

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MANUAL OF BUILD-OUT ANALYSIS

A Master's Project

Presented By:

Jeff Lacy

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The inspiration for this manual also comes from the many towns all across Massachusetts whose concerned citizens have endeavored to see into and shape their own futures. It is to these public spirited individuals that this edition is dedicated.

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OVERVIEW

This manual introduces the planning tool of build-out analysis, and describes, in a step-wise fashion, the data requirements, materials, and techniques necessary to complete both the graphic and numerical portions of the analysis.

The target users of this manual are planning boards and commissions, conservation and citizen groups concerned with growth management, and professionals in the fields of administration and planning. Although written for use in Massachusetts, it is equally applicable anywhere the needed data can be assembled.

Completion of a build-out analysis results in information that reveals visually what the landscape could look like, and numerically what the resulting population could be, given continued growth that is subject to the zoning ordinances and subdivision control regulations in place at the time of the analysis. As such, it can serve as an inspiration and catalyst for a process that can restructure applicable planning and zoning mechanisms in order to more faithfully reflect the needs and aspirations of a community.

The final product is a paper base-map, colored to show both the lands constrained from further development and those lands available for some form of conversion. In addition, a "see-through" overlay is produced, showing the pattern and intensity of the potential development on the buildable lands. The numerical analysis, as a derivative of the base-map, quantifies the extent of the transformation in terms of acreage consumed, and the number of new housing units, residents, and school children.

INTRODUCTION

Municipalities throughout New England have historically maintained a strong tradition of home-rule. Many of the functions normally assumed by county or regional bodies in other parts of the country are instead performed by individual towns. In Massachusetts, for example, most planning, zoning, and subdivision control authority resides at the municipal level. While there are some definite advantages to local autonomy, smaller, more rural towns often lack the necessary resources and/or expertise to adequately plan for, or manage, rapid ex-urban growth. In addition, towns frequently plan and zone without deference to, or consultation with, their neighbors. The result is often a fragmented "patchwork quilt" of land-uses and regulation, without any regional cohesion or long-term vision.

Residents living in growing areas rely upon the zoning regulations they adopt at Town Meeting to protect them from inappropriate suburban development, and to maintain the rural ambiance of their town's landscape. Unfortunately, the bulk of what constitutes conventional zoning and subdivision regulation does not ensure this outcome, but instead often mandates some form of conversion and development on all buildable land. In fact, these regulations serve more as suburban <u>development</u> standards than as protectors of natural resources, open space, or historic character. It is no surprise that many residents are repeatedly disillusioned as the classic, New England pattern of town and country settlement gives way to an undifferentiated "sprawl" of residential housing, office parks, and commercial "strips." Reflecting on these transformations at town meetings across the region, frustrated residents have echoed sentiments such as, "We thought our community was protected because we have zoning," or, "There was so much open countryside here just a few years ago - what has happened?"

A common reaction to development pressure is to increase minimum residential lot size in the mistaken belief that, as new homes are spread farther apart, the town's open, rural character will be retained. This method often produces the opposite result. The remaining open land is consumed at an even faster rate as property is divided into larger lots and mini-estates. To worsen the situation, such developments nearly always convert the entire property parcel being divided, leaving no residual open space for farming, forestry, recreation, or wildlife habitat.

The depletion of farmlands, forests, recreational lands, scenic roadsides, and other valued open spaces often occurs incrementally, over several generations. But, as such, may not raise public alarm until there is little left to be saved (Fig. 1).

Introduction to Build-Out Analysis

One way for towns to prevent, or at least anticipate, this unfortunate outcome is to preview or "test" their existing zoning ordinances and subdivision controls by performing a build-out analysis. This technique can estimate the effects that cumulative growth may have upon a town's land area once all developable land has been consumed and converted to the uses permitted under the current regulatory framework. What is more, it is well within the abilities and resources of most small towns to conduct this type of study themselves, without the expense of an outside consultant. The outcome can be particularly enlightening when the regulatory "status quo" does not seem to be working, or when there is good reason to predict that growth pressures are likely to increase in an area. This type of analyses can also be

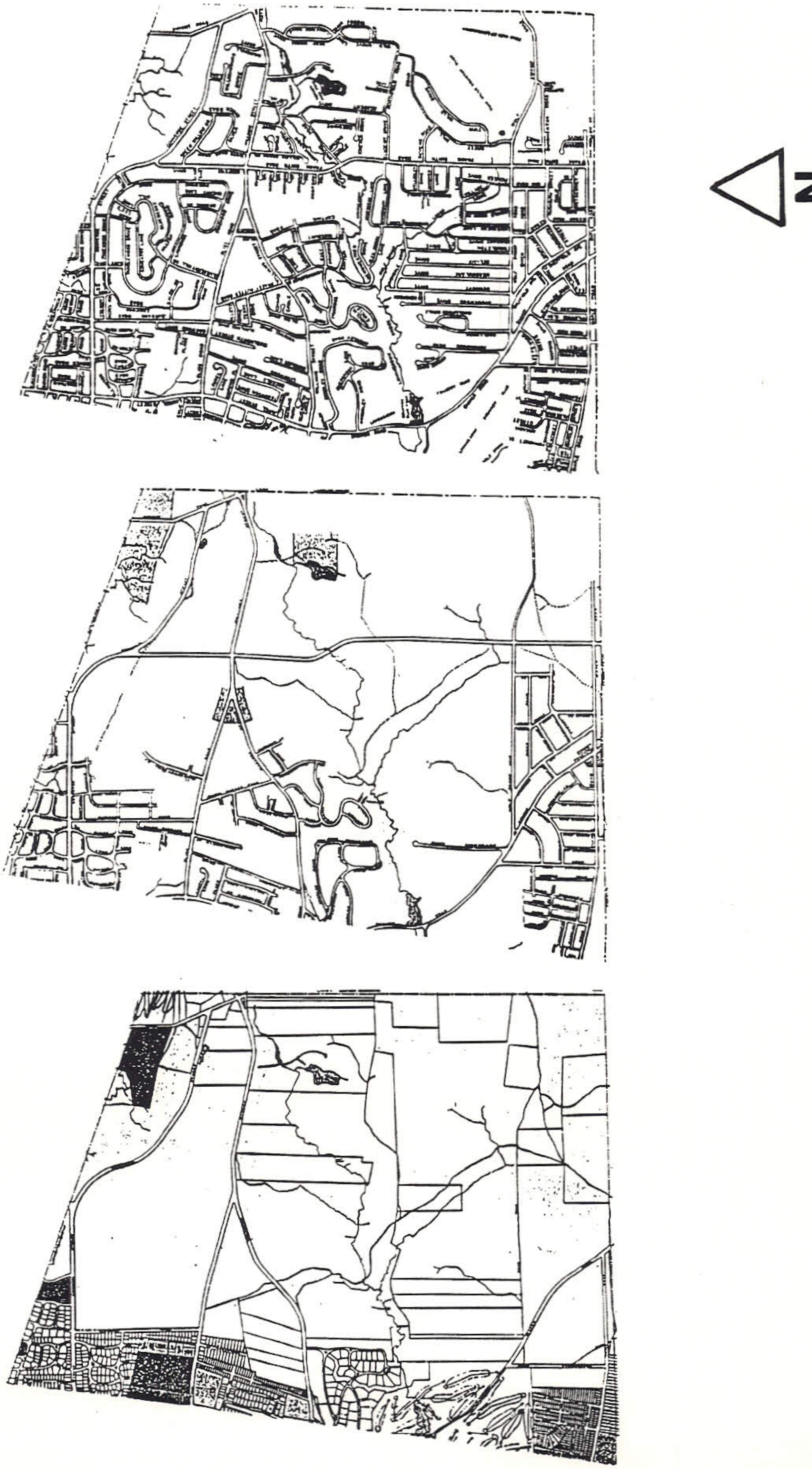

Fig. 1 Incremental build-out of a rural town in Massachusetts - 1942, 1957, 1987.

performed on a micro scale to demonstrate potential outcomes for specific areas such as highway or river corridors, business districts, or individual farms.

The build-out analysis extends a town's existing zoning and subdivision regulations out into the future, to illustrate the pattern that development can take when all remaining buildable land has been consumed. It does not predict when a final build-out will occur, but does accurately portray the potential for "wall to wall" residential subdivisions, shopping centers, and office parks. The numerical extent and spatial arrangement of this development can then be evaluated, given the full implementation of these land-use regulations. This glimpse into the future can be shocking, given the inherent vulnerability of the rural countryside for conversion to more suburban uses. The results of this exercise will help town officials make decisions concerning the direction of future planning and zoning initiatives on a more informed basis.

The information in this manual was derived directly from work conducted at the Center for Rural Massachusetts in preparation of build-out analyses for the Massachusetts towns of Ashby, Deerfield, Hadley, Huntington, Littleton, Sheffield, West Stockbridge, and Williamsburg. Additional exposure to this technique resulted from the author's work in the Connecticut towns of Bolton, Andover, Coventry, and Columbia, and in Essex and Pawling, New York.

Summary of Essential Steps

Working with source maps of the study area, lands constrained from development by virtue of public ownership, deed restriction, utility easements, pre-existing development, or natural factors (wetlands, floodplain, steep slopes) are delineated and then subtracted from the gross land surface in the study area. This process of elimination will yield a "net usable land area" (NULA) which, for the purposes of these investigations, is considered to be developable land. Needless to say, the more inclusive and precise the definition and identification of constrained lands, the more accurate the final estimation of NULA will be.

Once NULA has been established, the town's road standards and minimum lot-size and frontage requirements are applied across these developable lands in all zoning districts (residential, commercial, industrial, etc.), as if all the lands available for development were to be consumed instantly for there "highest and best use." In this way, a reasonable estimate of potential new units may be made. From new units, projections for associated population growth, infrastructure needs, and increases in school-age children and traffic are possible as well. These results may be portrayed in both numerical form (tables) and graphic form (charts and maps).

It is suggested that these analyses be limited to an estimation of residential build-out only. Commercial and industrial activity, although a generator of traffic congestion and water and sewer demand, is much more limited in spatial extent, results in no direct addition of residents or school-age children, and is considerably more difficult to quantify accurately.

SOURCES OF DATA

Much of the baseline information for the build-out analysis is available from existing maps, although these are often found at different scales. Recently-taken aerial photos are also useful for updating cultural features. Additional zoning and property parcel information can be obtained at local town offices. It is also beneficial to check with the appropriate regional planning agency, as much of the preliminary mapped information may already be available at these offices. Other specific sources of information include:

U.S. Soil Conservation Service (USDA) - medium-intensity soil maps with manuals explaining their use.

U.S. Geological Survey (USGS) - topographic quadrangles. For fast delivery of these essential maps call: Timely Topos at (800) 821-7609.

Cartographic Services, UMASS, Amherst, MA (413) 545-0359
-all manner of maps for sale, good advice.

Resource Mapping/Land Information Systems, Dept. of Forestry and Wildlife Management, UMASS, Amherst, MA (413545 3589 -aerial photos, land-use maps.

Standardization of Map Size

Mapped information comes in different sizes. However, in order to utilize this information, mapped features will need to be traced directly from the original maps onto some form of composite map. To do this accurately, all of the source maps must be of the same size. From our experience, at least some photo-reduction or enlargement will be necessary in the course of preparing the base map. This is best accomplished by a copy-shop capable of handling the large-format (30-36 inches) necessary. If extensive size adjustments are required, these costs can be a significant part of the budget.

Map Scales

Scale is defined as the relationship between distance on the map and the corresponding distance on the earth's surface. Two types of scales are frequently encountered, although both are simply different ways of expressing the same thing, and, as such, are interchangeable. The first is a ratio scale, whereby one unit of anything equals so many of the same thing on the ground. This type of scale appears as 1:24,000 for example, where one inch (or foot, or yard) on the map equals twenty-four thousand inches (or feet, or yards) on the ground. Whatever units of measure are used, the ratio between what is on the map and on the ground remains constant.

The second type of scale is an exact delineation of what a specific interval on the map equals on the ground. It states just what one inch will translate to in feet on the ground. Scales that are used in site-specific planning are often in the 1" = 40' or 1" = 100' range. These scales produce sizeable, more detailed maps and therefore are commonly referred to as large-scale maps. A build-out analysis performed at these scales would be very accurate, but impractical due to the size (approaching a wall-sized mural) and preparation time.

In the terminology of mapping the designations of "small" and "large" scale can be confusing. Small and large are really just relative terms that have meaning only when comparing two different maps. Maps of small areas, such as property parcels, are called large-scale maps because they provide larger, more detailed information. Conversely, maps of larger areas will contain less detailed information for the same given area, and are referred to as small-scale maps. For example, a larger, ratio scale of 1:12,000 (1" = 1,000' as a specific scale) will provide far more detail than a smaller scale of 1:62,500 (1" = 5,208' as a specific scale). See Fig. 2.

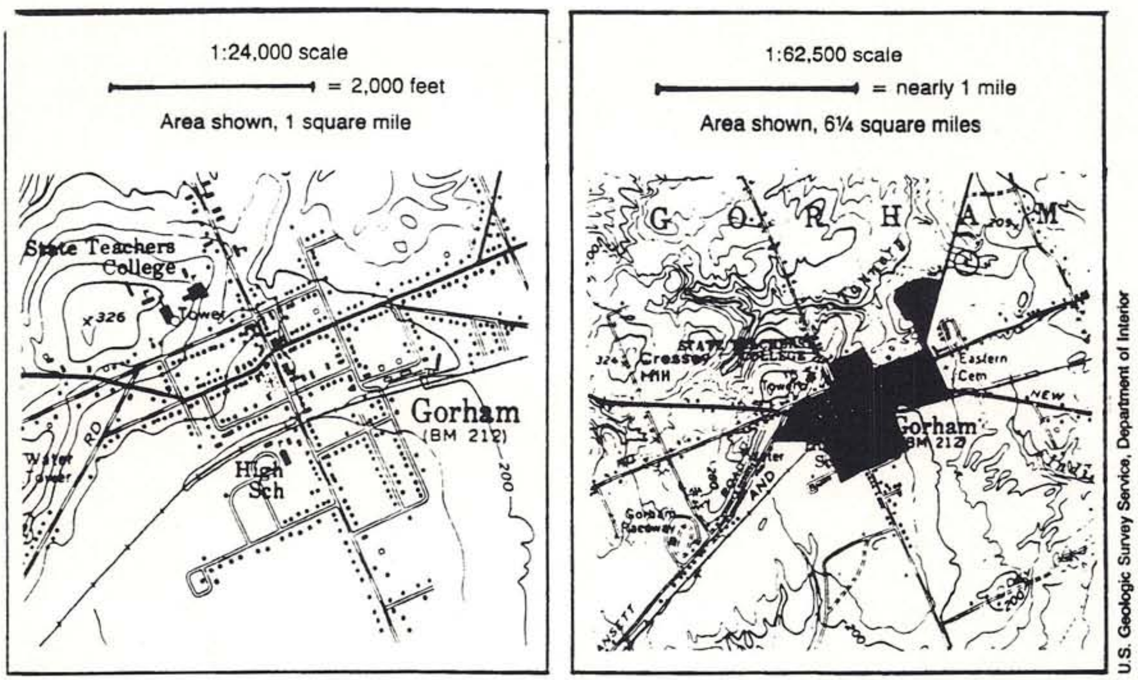

Fig. 2 Comparison of a large-scale map (left) and a small-scale map (right).

For most Massachusetts communities, a specific scale in the range of 1 inch = 800 feet to 1 inch = 1200 feet will be appropriate, depending upon the size of the town. In this way the entire map will fit on the 36-inch wide paper commonly available at most art and graphics supply stores.

Almost without exception, maps of different scales will require standardization before they can be used as overlays. Prior to calculating a magnification or reduction factor, the "before and after" scales of both maps must be standardized as either ratio or specific (remember what they say about mixing apples and oranges). The following example will illustrate how to standardize the frequently encountered ratio scale of a USGS topographic quadrangle, and how to calculate the magnification factor needed to produce a specific scale appropriate for a finished build-out analysis map.

Example

Problem:

Given a USGS topographic scale of 1:25,000, what magnification factor will the copy shop use to increase the size of the map to arrive at a finished scale of 1" = 1,000'?

Solution:

Change both scales to ratio (or specific if you wish). Since there are 12 inches per foot, conversion of 1,000' to 12,000" yields 1" = 12,000", which is the same as a ratio map scale of 1:12,000.

To determine the magnification factor, use the following equation:

$1/25{,}000 * X = 1/12{,}000$

-where X represents the unknown magnification factor.

(In this equation you are multiplying the smaller map by a magnification factor of greater than one in order to generate the larger map.)

Perform the necessary algebra to solve for X.

$1/25{,}000 * X = 1/12{,}000$

$X/25{,}000 = 1/12{,}000$

$X = 25{,}000/12{,}000$

$X = 2.083$

Answer:

2.083 is the exact magnification factor the copy shop will use to bring the smaller map up to a 1" = 1,000' scale.

The same methodology can be used to calculate a <u>reduction</u> factor. A simple modification of the initial equation is all that is necessary. For example, start with $1/12{,}000 * X = 1/25{,}000$, where X is a fractional reduction factor (less than one) that is multiplied by the scale of the larger-sized map in order to produce a smaller map.

The following example will illustrate a common map-reduction exercise:

Example

Problem:

Given a series of assessor's maps at a specific scale of 1" = 400', find the reduction factor necessary to match a base-map scale of 1" = 1,000'.

Solution:

Since both maps are already have a specific scale, no standardizationis necessary.

Use the same type of equation for reduction:

$$1/400 * X = 1/1,000$$

Perform the algebra to solve for X.

$$X/400 = 1/1,000$$

$$X = 400/1,000$$

$$X = 0.4$$

Answer:

0.4 is the exact reduction factor the copy shop should use to bring the assessor's maps down to the appropriate size.

In order that the work performed by the copy shop be precise, an easy checking system is recommended. If a magnification factor of 2.083 is required, then a ten-inch line on the original map should show up as 20.83 inches on the enlargement; or, for a reduction factor of 0.4, a ten-inch line will show up as 4.0 inches on the reduction. Drawing such a line on the original will enable you and the copy-shop person to check the work before proceeding ahead. The longer the line drawn, the more accurate it will be as a checking device.

BASIC SUPPLIES

When finished, your build-out map will consist of a paper base-map, colored to show both constrained and developable lands, and a clear overlay sheet depicting the potential development on those lands. The materials needed to produce these maps, and to conduct a follow-up, numerical analysis are:

1. double-sided drafting film - 3 ft. by 5 ft. minimum.

2. black-line, diazo paper - In theory, a sheet 3 ft. by 5 ft. is all that is required, but it generally comes in larger rolls. Get the thickest paper available.

3. clear polyester film - Try to obtain polyester, which is more resistant to tearing than acetate; get the thickest film possible.

4. drafting pens - Three tip sizes can be interchanged onto one pen body to lower costs. Recommended tips are 0.5mm, 0.8mm, and 1.3mm. Note: Tips should be cleaned thoroughly after each use to prevent clogging.

5. black drafting ink - Waterproof.

6. ink eraser - Get one that is imbibed with erasing fluid, otherwise it won't work on waterproof ink.

7. T-Square - 36 inches long.

8. triangular straight-edge - Make sure it has a double "ink edge" to prevent smearing.

9. ruler - Three-sided, engineering "scales" are the best.

10. flexible ruler with ink edge - Useful for copying gradually curving road lines smoothly. Also helpful for those of us with shaky hands!

11. "exacto" knife - Scissors are not recommended for precise cutting of finished products.

12. "press-on" lettering - Many sizes and styles are available. A good standard set would include helvetica medium - 84 pt., 42 pt., and 24 pt.

13. pressure-sensitive graphics tape - Get a solid line for the map's outer border, and a dashed line for the municipal border. In the case of an irregular, curving municipal border, it may be easier to draw the border in pen rather than to use tape. If there are major state and interstate highways in town, you may wish to use black tape (neater looking) rather than a pen to delineate them.

14. marker pens - These are used to color the paper base maps; they come with both fine and broad tips. The following colors should suffice for most build-out maps: black, medium-red, purple or green, blue, and yellow.

15. soft brush - To keep working surface free of eraser debris.

16. drafting film conditioner (This is a powdered substance that prepares the surface of the drafting film to take ink after an erasure has been made.)

17. dot-grid or planimeter - One or the other of these devices will be required to determine the areas of various parcels on the base map.

Note: If not familiar with these materials, take this list to an art or graphics supply store for clarification.

CREATING THE BASE MAP

The creation of a base map is the bulk of the work in the overall build-out analysis. Great care must be exercised in its construction as it is the foundation for subsequent numerical analyses and for determining NULA. Although the final base map will be on colored-up paper, all of the initial drawing should be done on thick, double-sided drafting film. Drafting film is better for this purpose because mistakes can be more easily erased. Paper is far less forgiving. Once all available information has been rendered on the film, paper prints (ready for coloring) can be readily produced on a diazo ("blueprint") machine or large-format xerox copier.

The following features should appear on the base map:

* Black-line perimeter border
* Dashed-line municipal borders
* North arrow
* Legend
* Title block(s)
* Scale

Within the municipal border, the following should be shown:

* Existing roadways
* Developed lands
* Public lands and lands permanently constrained from development

through deed restrictions, conservation easements, etc.

* Water bodies and major rivers
* Wetlands
* Steep slopes
* Developable lands (NULA)

Figures 3 and 4. show a base map in two stages of completion, from drafting film/paper print, to finished, colored-paper, base map.

Getting Started

What follows is a step-by-step description of the process for adding each component to the base map. These steps are not necessarily presented in any specific order, since that may vary with individual preference. As in all lengthy and detailed work, a comfortable work surface with ample lighting is essential to one's spinal and mental well being. A "tiltable" drafting table with direct incandescent light is optimal.

The first step (and this should be the first step) is to trace the outline of the municipal border on the drafting film. Use the USGS topographic quadrangles for this purpose once they have been properly enlarged and taped together. Care must be taken so that the entire outline of the town fits within the confines of the 36-inch wide paper (the selection of an appropriate finished scale will make this possible). Space must also be left in for a border line and for title blocks, north arrow, legend, etc. The final orientation of the town on the film should be such that, when the map is presented, the north arrow is as nearly vertical (pointing up) as possible. Most viewers relate better to this typical orientation.

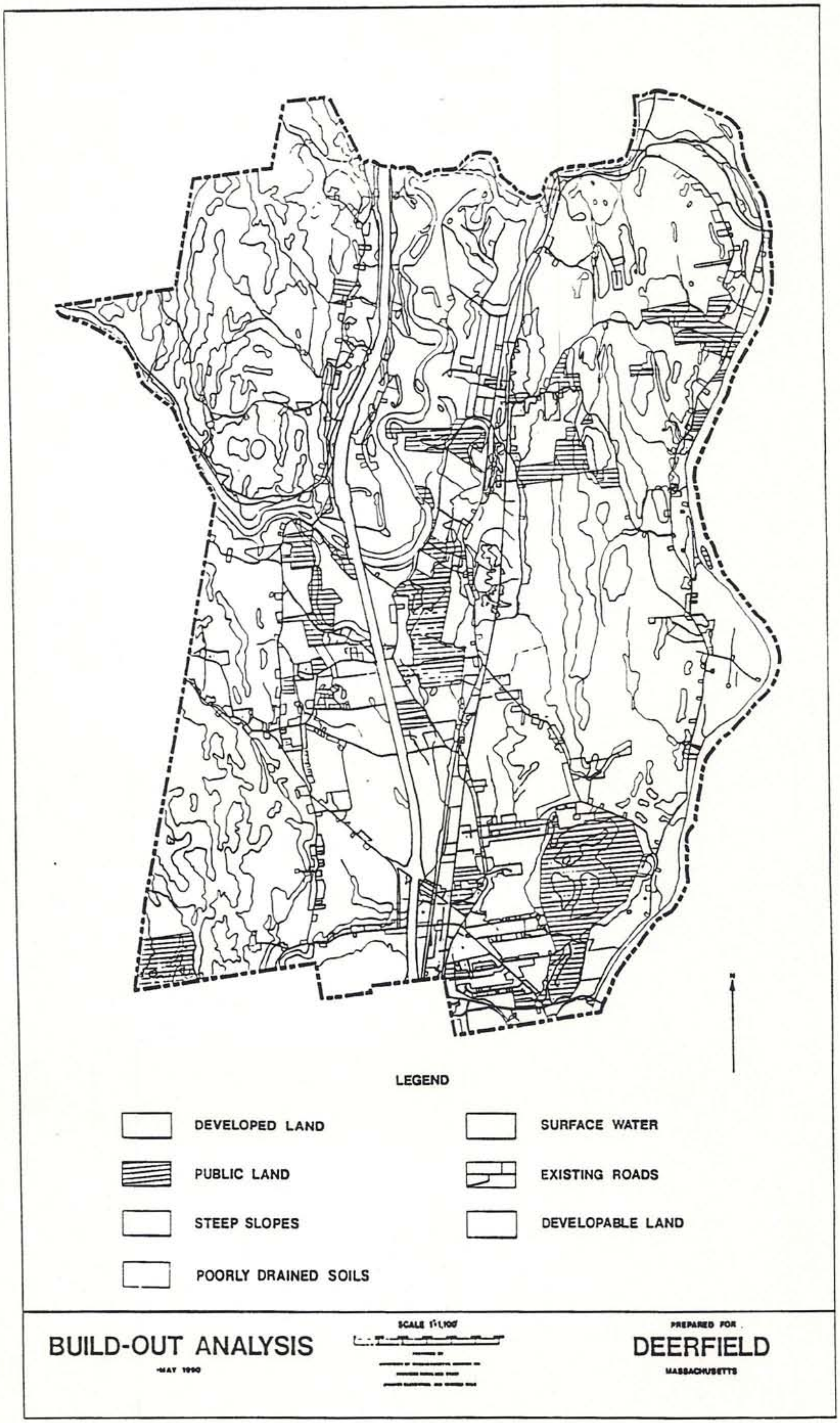

Fig. 3 A paper print of the base map, generated from drafting film.

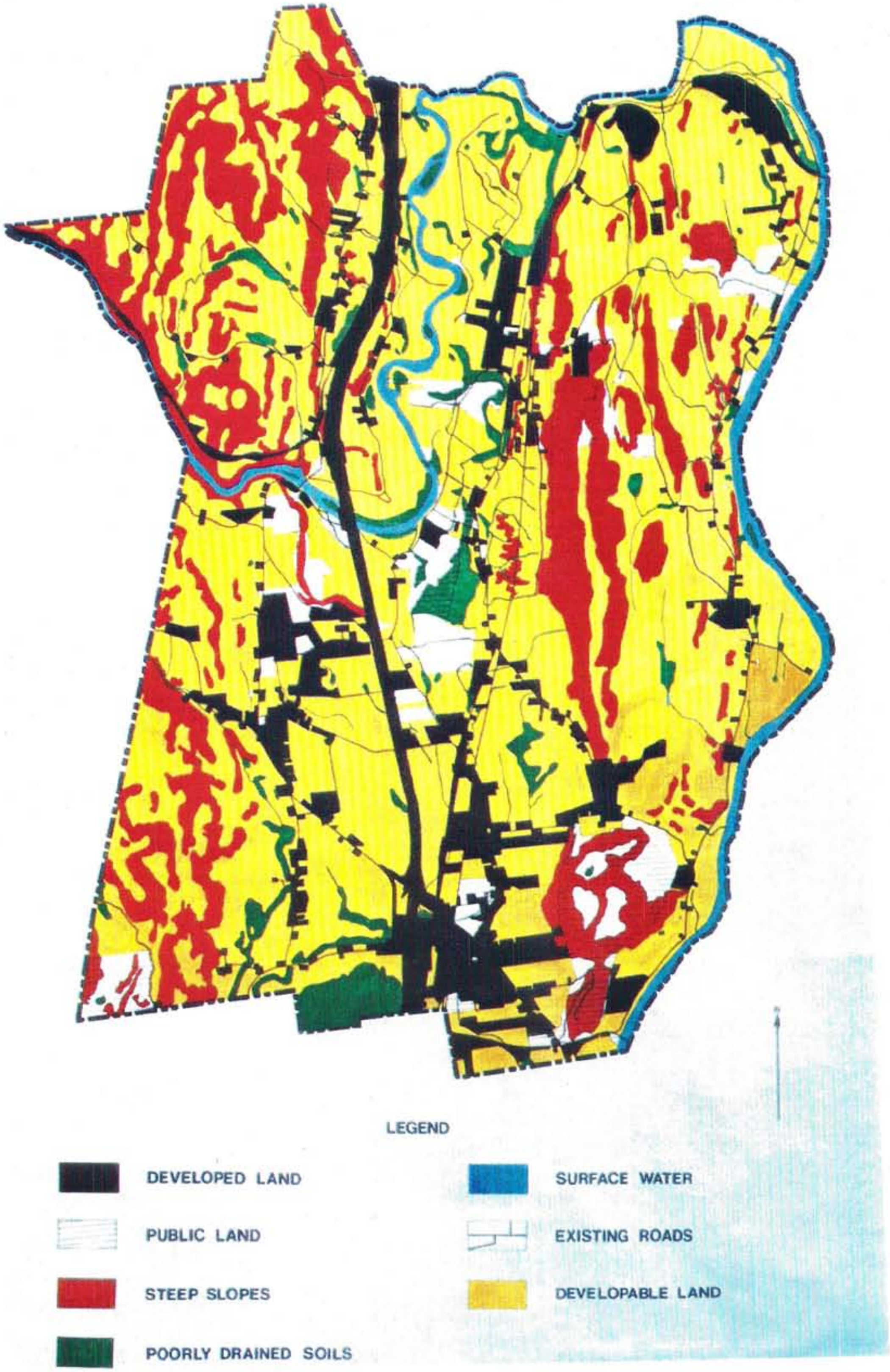

Fig. 4 Colored-up paper base map.

Use the T-square and exacto knife to cut a suitably-sized piece of drafting film. Refer to Figure 3 to see how the various elements on the map are arranged.

Black-Line Perimeter Border

This is a cosmetic touch that sets off the map by framing it with a solid black line. The line should be applied to the drafting film using pressure-sensitive drafting tape of a thickness between 1/8th and 1/4 of an inch. Leave a 1/2 to 3/4 of an inch margin between the outside of this line and the edge of the film. That should also be the minimum distance between the inside of the line and any mapped feature or lettering, to avoid a crowded appearance.

Dashed-Line Municipal Border

It is important to clearly delineate the boundary of the study area with a dashed, black and white line. A suggested pattern of dashing is one long dash followed by two short ones, etc. This and other patterns are available in pressure-sensitive drafting tape. In the event that a municipal border is highly irregular (i.e., curving switchbacks as are often found along meandering streams), it may be more practical to hand-draw it using a thick pen or marker rather than tape.

North Arrow

There is considerable flexibility in the placement and design of the north arrow, but make sure the arrow points toward "true" (directional) north rather than magnetic north (Note: USGS maps are oriented toward true north; surveyor's maps often use magnetic north). You may wish to consult other maps for design inspiration, or use one of the pre-made north arrows available at graphics- supply stores.

Legend

A legend serves to identify and define mapped features. A well-conceived legend will increase the reader's understanding and effective use of the map. Ample space must be provided for the legend. Press-on letters of the intermediate size (42 pt.) work well for this purpose. The top line should say LEGEND, starting at the left margin. Each successive line down from this should start at the left margin with an outline box (approx. 1 in. * 2 in.), a space, and then a short title (Figs. 3 and 4). The standard titles are DEVELOPED LAND, EXISTING ROADS, PUBLIC LAND, STEEP SLOPES, WETLANDS, SURFACE WATER, and DEVELOPABLE LAND. Later on, these outlined boxes will be either colored-up or will have representations of a mapped feature added to them. Be sure to leave space at the bottom for one additional legend item to be added at a later time (see CREATING THE OVERLAY).

Title Blocks

Title blocks generally look best at the bottom, running the full length of the map, and separated from the rest of the material by a horizontal line. Upper-case, press-on letters of various sizes are appropriate. The following information is generally shown:

Title of Map - "Build-Out Analysis," in largest letters.

Date of Map - date of completion, in intermediate size letters.

Study Area - name of town, county, or region, along with the state, all in largest letters.

Client or Sponsor - whoever commissioned the study, in intermediate size letters.

Preparer - who prepared the map, name and address in smallest letters (give yourself some credit here, but be modest).

Sources - where the information came from (i.e. USGS, SCS, Tax Assessment Maps), in smallest letters.

Scales

The proper scale should be stated in two ways. The first is with scale "bars", one in feet and the other in miles. Consult most professionally-prepared maps for examples of scale bars (Fig. 5). The second representation is in words. Lettering positioned over your scale bar should say - SCALE 1" = 1,000', or whatever it is. Those familiar with map interpretation would refer to this as a "thousand-scale" map.

See Figure 6 for the locations of the features described above.

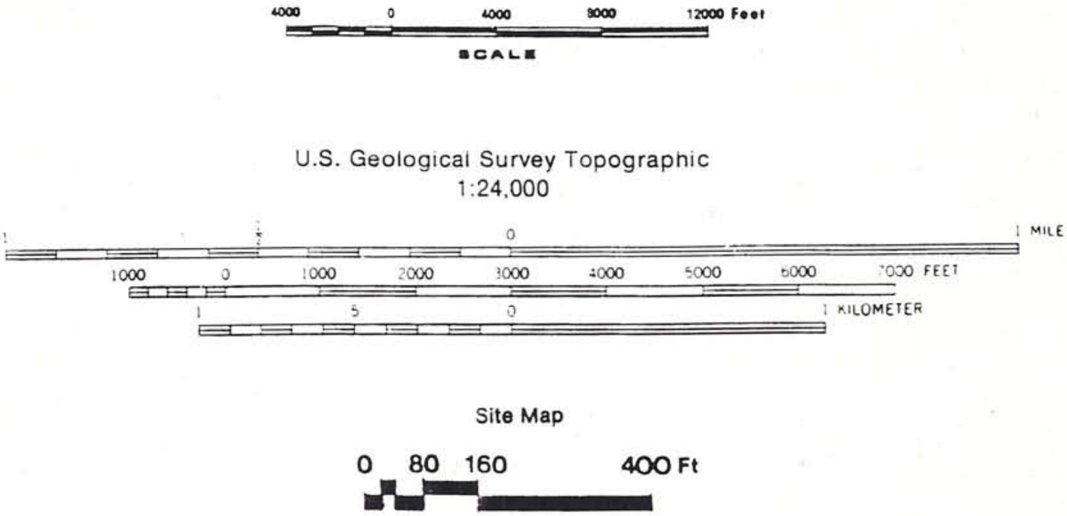

Fig. 5 Examples of scale bars found on modern maps.

Existing Roadways

After the municipal border is outlined, the drafting film can be easily re-aligned exactly over any other map (of the same scale) as an overlay. Once precisely positioned over the most recently photo-revised USGS map obtainable, existing roadways can be traced onto the film. Different width pen tips can be used to differentiate amongst local, state, and interstate highways. Where wide rights-of-way can be identified, as are often found bordering limited-access highways, blacken in the entire area. Allow adequate time to make sure these roadway lines are drawn in smoothly, using the flexible ruler if needed. Black, pressure-sensitive tape may be used instead of a pen to delineate major highways. This works well for roadways that are fairly straight, and results in a neater overall appearance.

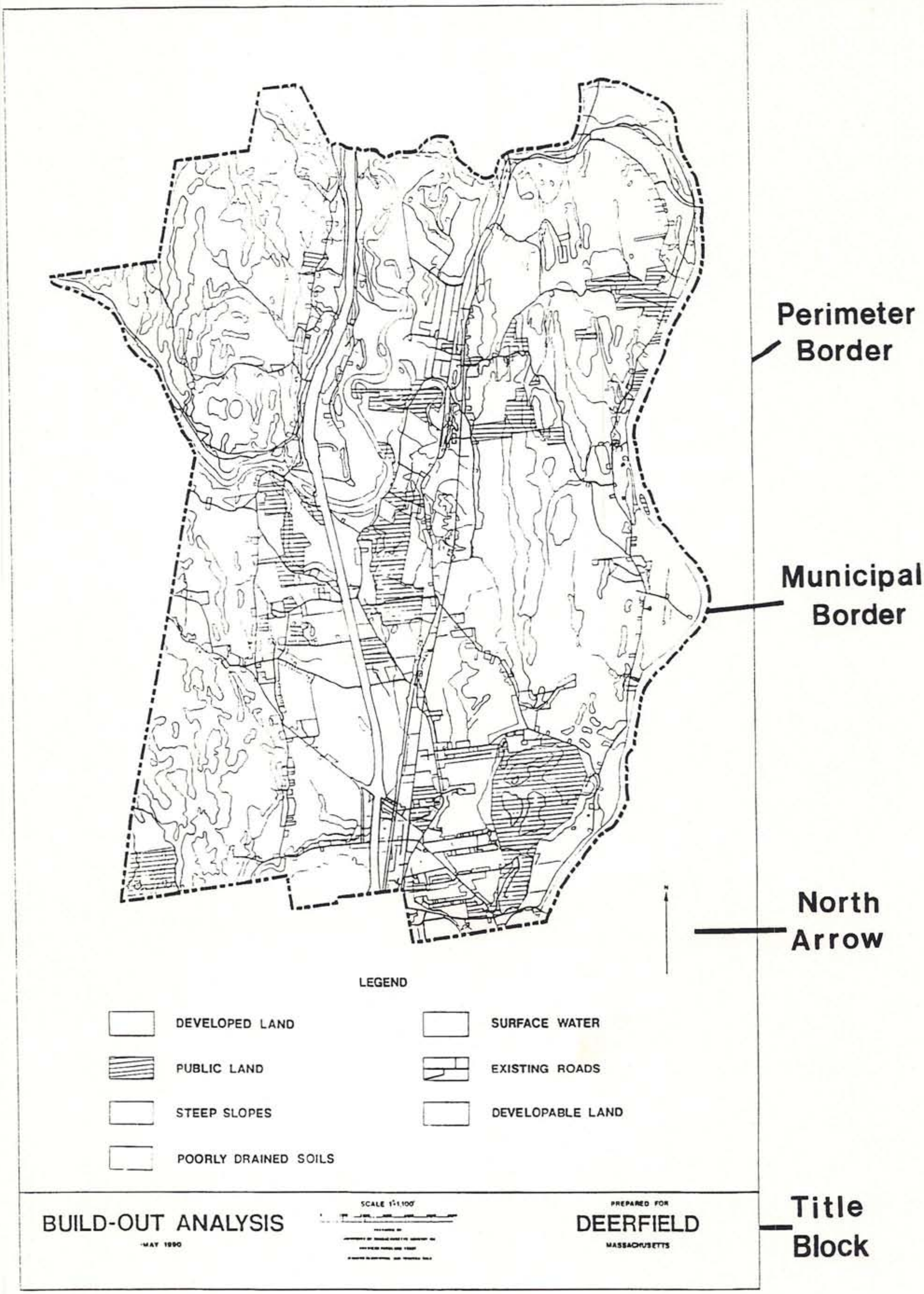

Fig. 6 Base map showing locations of perimeter border, municipal border, north arrow, legend, and title blocks.

Developed Lands

Accurately representing developed lands on the base map is perhaps the most arduous, and can be the most arbitrary phase in the process. The drafting film (complete with town border and roads) is be placed over the USGS map. The location of every structure (signified by a solid black rectangle or square) should be noted by placing a "dot" on the film. Next, use aerial photos (if available) to further update the addition of more recently constructed structures. An even more accurate portrayal of developed lands can be achieved if approved, but as yet unbuilt, projects are also included. The planning board is the best source for this information.

Every dot now represents a structure of one kind or another, although the majority will probably be single-family, detached homes.

The next phase is a bit tricky, and involves some intuition (or educated guesswork), and takes some time to master. Individual lot-lines must be drawn around each of the structure dots. These lot areas will eventually be blacked in entirely, representing lands that are already developed.

Lot areas are delineated according to the dimensions, size, and frontage requirements specified in the current zoning regulations. There is no way to know (other than with an overlay map that depicts the boundaries of every property-parcel) just how large or small someone's individual lot is from just a dot on a map. However, the underlining assumption in build-out analysis is that all available land will be fully utilized. Therefore, land owners will sell off any lands they own in excess of that which is required for a legal building lot around their existing structure. To be realistic, nearby barns and other "out-buildings" (depicted on USGS maps as hollow rectangles and squares) should be included in the lot area retained with an principal structure.

A single structure along a highway can simply be enclosed by a square or rectangle that contains the minimum legal lot size and an adequate frontage distance on the street in accordance with the applicable regulations for the underlying zoning district. Extensive residential subdivisions, with curvilinear streets and houselots laid out in a "grid" pattern, can be outlined and blackened in their entirety. In more arbitrary spatial layouts, the aerial photos may help to make these designations more accurate. Again, experience with property-parcel maps and in performing a number of these analyses will increase your proficiency.

Public Lands

For the purposes of these analyses, lands are considered constrained from further development by virtue of deed restriction, and/or ownership by a municipality, the state or federal government, or a non-profit organization. Although exceptions do exist, this is a conservative, but prudent, assumption to make.

Public lands may or may not have been previously mapped. Towns that have completed open-space plans or who have retained the services of a consultant to produce a "master plan" are likely to have maps delineating public lands in their reports. USGS topographic maps do outline most state and federal parks and holdings. Parcel maps, kept by the town assessor, are a very accurate source of information. However, in order to be useful (i.e. traceable onto the base map), these parcel maps must be reduced to the same scale as the base map.

Once the outlines of all public lands are on the drafting film, use a pen and the T-square to "hatch" (fill in) these holdings by drawing straight, horizontal lines across the parcels at intervals of one-quarter inch or so.

In the event that no mapped information is available, an acreage figure for public lands might be obtained from the assessor. This value, although not mappable in any meaningful way, can be used in the numerical analysis described later in this manual.

Water Bodies and Major Rivers

The locations of lakes and major rivers are taken from the USGS topographic maps and added to the base map using drafting pens. Major rivers are defined as those with a visible width on the USGS topographic map. Disregard streams that are represented by a single line on the map. These smaller watercourses are generally subsumed within the "wetlands" designations made later.

Wetlands

Wetlands may be delineated in a number of ways depending on the criteria used and the agency responsible. In general, these areas are unsuitable for development due to the presence of standing water, a seasonably high water table, and/or poor drainage characteristics (periodic saturation) during most or all months of the year. There are a number of wetland types including marshes, swamps, bogs, and some floodplains. Their soil characteristics make the building of structures and roads impractical, if not illegal under statewide wetlands-protection legislation.

The best source of mapped information on wetland soils is the county office of the Soil Conservation Service (SCS). The SCS publishes a soil survey with maps for every county in Massachusetts, usually at 1:24,000 or 1:25,000 scale (Fig. 7). Once these maps are enlarged and pieced together, the appropriate soils groupings can be traced onto the base map.

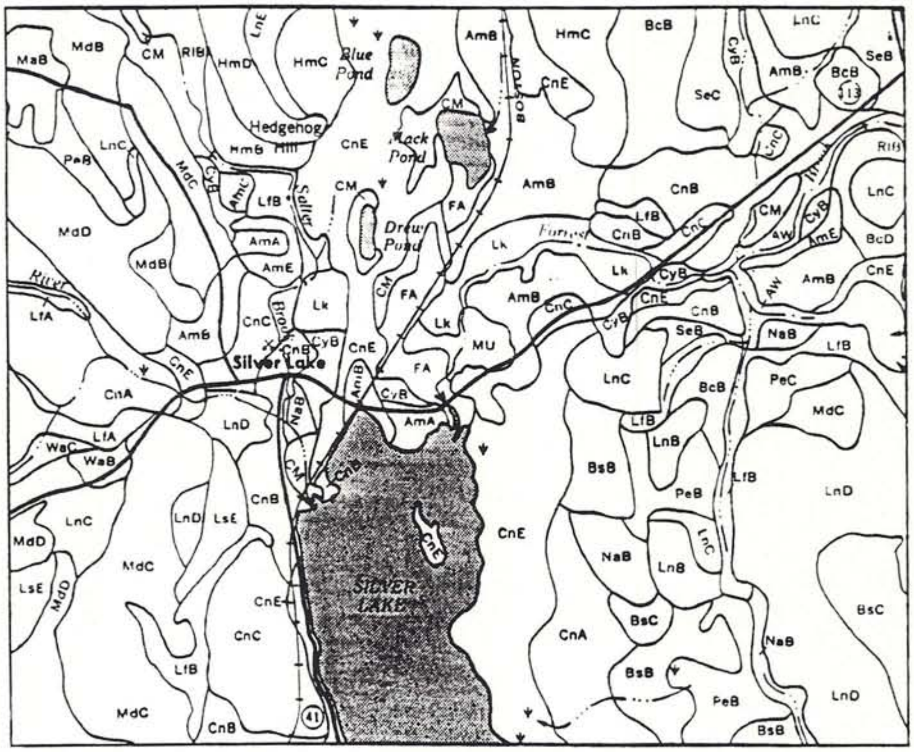

Fig. 7 Portion of a standard U.S. Soil Conservation Service map.

Soils that should be included as wetlands in these analyses are aggregated as Inland Wetland Soils. This category includes poorly drained soils, very poorly drained soils, and alluvial soils, as designated by the National Cooperative Survey.

Poorly drained soils have a water table at or near the surface from late fall to early spring. These soils occupy nearly level and very gently sloping areas.

Very poorly drained soils have a water table which remains at or above the surface most of the year. These soils occupy level or depressed areas.

Alluvial soils are formed from sediments deposited by water on floodplain, and consist primarily of sands and gravels. They occupy nearly level areas and are subject to stream flooding. These soils can actually range from very poorly drained all the way to excessively drained.

Soil-survey maps from SCS are an excellent guide for identifying areas dominated by wetland soils. However, at the published map scales, the smallest areas which can be represented are approximately 2-3 acres. Therefore, smaller areas of wetland soils may actually occur within mapped areas of non-wetland soils, and vice versa. Although adequate and appropriate for this type of analysis, any map based on soils information cannot take the place of a detailed, on-site evaluation of a parcel for determining the precise location and extent of its wetlands.

The best way to locate and scribe wetland soils boundaries onto the base map is to first make a list of all of the map units in the county's particular survey which qualify as wetland soils. The SCS has, in some cases, already performed these aggregations on a statewide basis. These units generally will have only two letters, as a third letter is only used to designate a steeper slope than would be found in wet areas. Some examples of qualifying units are Am (Alluvial land), Pk (Peat and Muck), and Sa (Saco fine sandy loam). With this list in hand (and soon to be in memory), outline all the matching soils boundaries onto the drafting film.

Be sure that, as these irregular shapes are scribed onto the film, whether they be water bodies, wetlands, or areas of steep slope, notations are made so that they can be differentiated from one another. For example, a lightly drawn "S" within a boundary will distinguish it as an area of steep slopes rather than a wetland. Another method is to use a different line type for each of the designations (e.g. continuous line for water bodies, dotted for wetlands, dashed for steep slopes, etc.).

Steep Slopes

In Massachusetts, state regulations limit construction on or near wetlands. No such statutory limitations exist for construction upon steep inclines, however inadvisable it may be. Nonetheless, engineering costs and access can be limiting factors. Most towns, as a part of their subdivision control law, specify that new streets not exceed a maximum slope of 10, sometimes 12%. This requirement discourages extensive new development in hilly terrain, but also allows subdivisions to be created, often with deep roadway "cuts" and "fills" to meet street-construction standards.

Slope, as the measure of surface steepness, is defined as the ratio of vertical "rise" to the horizontal "run," or "rise-over-run." It is represented as a percentage by the following formula:

RISE/RUN * 100 = % SLOPE

Substituting in the appropriate heights and distances, the slope of the hillside in Figure 8 can be expressed with this equation:

6 ft./60 ft. * 100 = 10% slope

Therefore, on this grade, for every 60 feet of horizontal travel, 6 feet in elevation is gained (or lost).

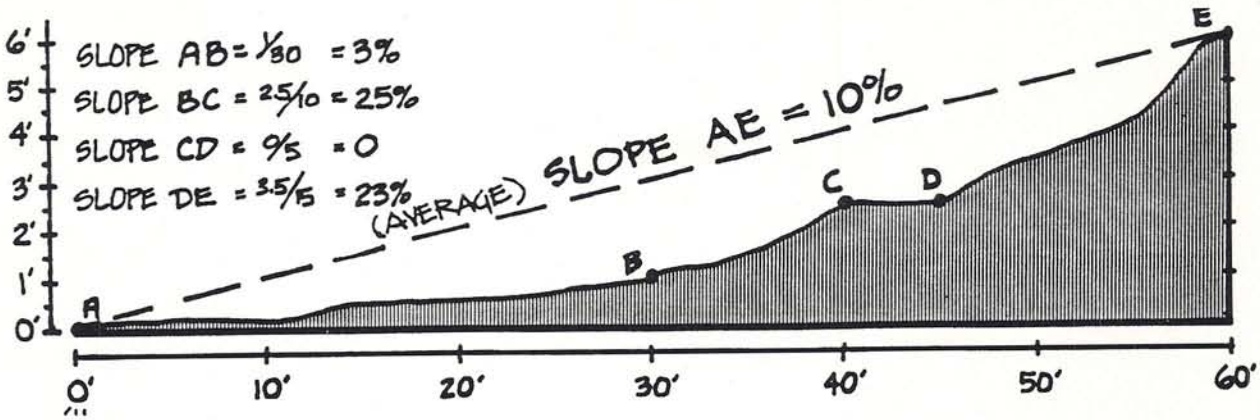

Fig. 8 Hillside with an average slope of 10 percent.

For the purposes of the build-out analysis, a slope "threshold" is selected by the preparer, beyond which development will not occur. The exceptions will be few, and can be ignored. These cut-offs can range from 15% (conservative) to 25% (stretching it). Twenty percent is a safe compromise.

Of course, in the real world there is no absolute cut-off. A more realistic way to portray slope constraints is to divide the land area into three categories of steepness; less than 15% slope, 15% to 25% slope, and greater than 25% slope. Subsequently, in the numerical analysis, development can be differentially ascribed to lands in each category, (e.g., full development density, as permitted by the zoning, on slopes less than 15%, one-half density on slopes between 15% and 25%, and no development on slopes greater than 25%).

To delineate areas of steep slope on the base map, a vertical and horizontal measure must be known. USGS topographic maps include both pieces of information. The scale of the map allows ready measure of the horizontal distance, while the map's contour lines show elevations above sea-level at any point. Contour lines are really <u>iso-elevation lines,</u> along which vertical heights above sea-level remain constant (Fig. 9). Generally, the "contour interval" on USGS topographic maps is 10 feet; which means that going from one contour line to the next will result in an elevation change of 10 vertical feet (up or down as the case may be). The closer these contours are to one another, the less the horizontal distance necessary to rise a given amount, or the steeper (higher percent) the slope. It is the combination of changing contour lines (rise), and the scale (run) which enables a definition of slope on these maps (Fig. 10).

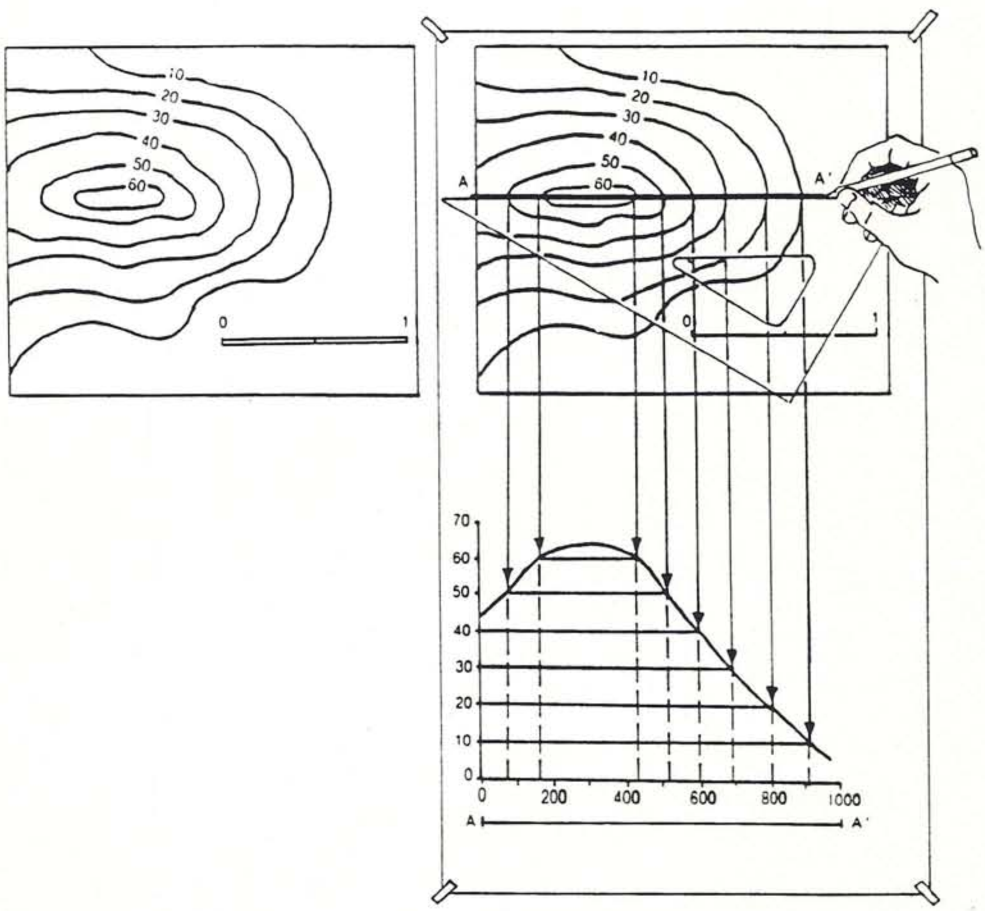

Fig. 9 Contour lines on a topographic map.

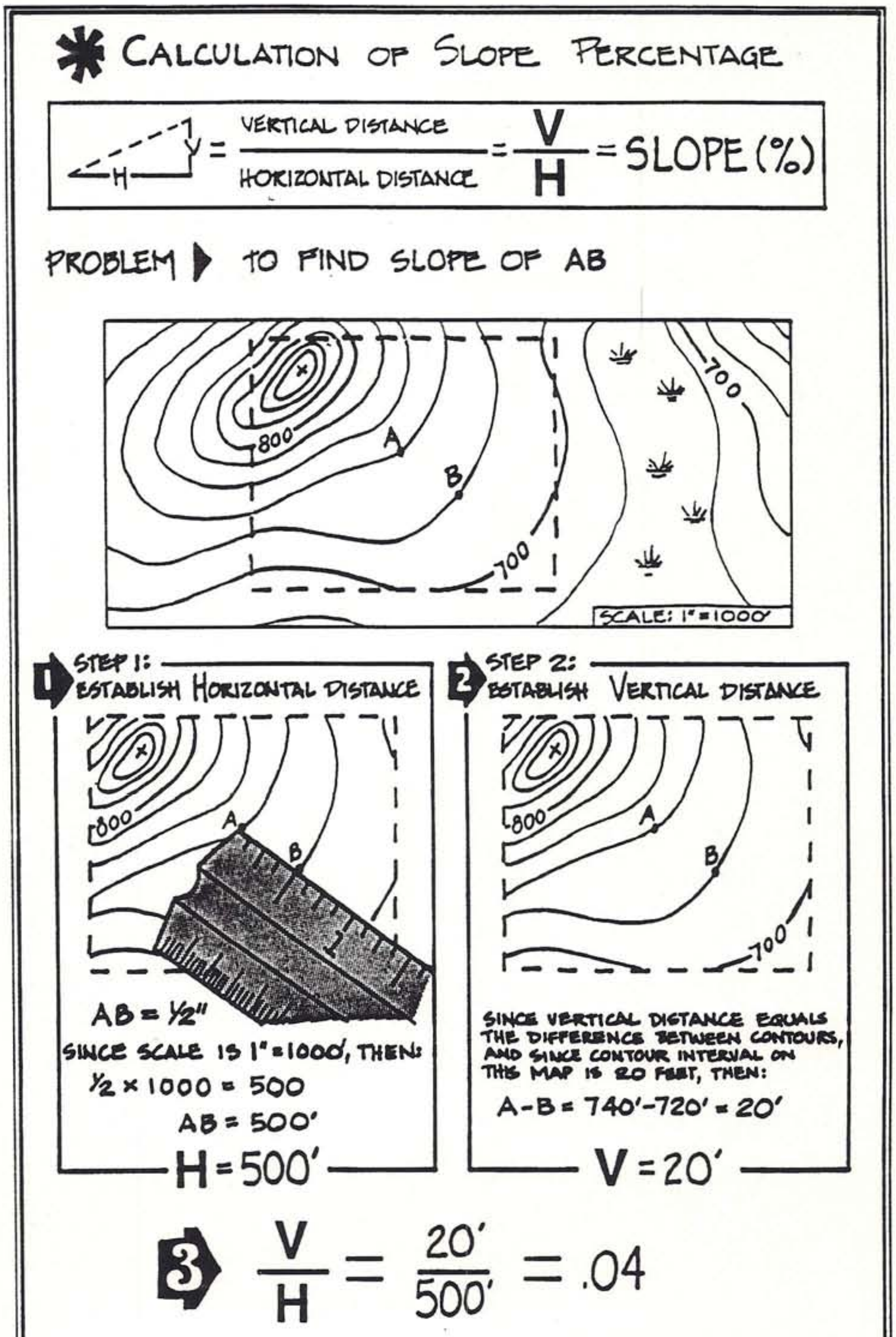

Fig. 10 Calculation of slope percentage from a topographic map.

To transfer the appropriate slope boundaries onto the base map, first position the drafting film over the USGS map. Outline the appropriate slope areas using a drafting pen. An eraser, drafting film conditioner, and brush should be kept close at hand as mistakes and revisions are to be expected. The following example illustrates the methodology:

Example

Problem:

Outline areas with a slope of greater than 15% on a USGS topographic map that has been blown up to a scale of 1" = 1,000', with a contour interval of 10 feet.

Solution:

The areas to be outlined are those which contain contours of a certain closeness to one another. <u>The determination of just how close together the contours must be is the crux of this exercise.</u> USGS topographic maps with a contour interval of 10 feet show every fifth contour line darker than the rest. <u>These darker lines are the best ones to use;</u> in effect, a 50 foot contour interval.

1.) Determine the horizontal distance (run) between the darker contour lines for a slope of 15%. Use the slope equation - RISE/RUN * 100 = % SLOPE, with a RISE of 50 feet, and a desired SLOPE of 15%.

Substituting, the equation becomes:

50 ft./RUN *100 = 15%

Solving:

50 ft./RUN = .15

RUN = 50 ft./.15

RUN = 333 ft.

2.) Determine what 333 ft. is on the map (i.e., how long a 333 ft. line would be).

At the map's scale (1 inch = 1,000 ft.), 333 ft. on the ground would be 1 inch * 333 ft./1,000 ft., or 0.333 inches on the map.

3.) Outline areas on the map where the darker contours are closer together than 0.333 inches.

Make a small "scale" on a scrap piece of drafting film that shows 0.333 inches. Use this as a "see-through" guide for measuring the perpendicular distances between contours. Trace the outlines for the areas of 15% or greater slope by copying directly over the darker contours. Whenever the distance to the next adjacent contour line approaches 0.333 inches, the line must "jump" to that next contour (Remember that contour lines farther apart than 0.333 inches will represent land with slopes of less than 15%). These jumps can be abrupt, with straight-lines connecting the contour lines, or they can be rounded off, depending on individual preference. Continue the line in this fashion until it either encloses the area or goes off the map (Fig. 11).

Identify and outline all 15% slope areas in this way.

Result:

Based upon these outlines, two slope categories have actually been created - less than 15% and greater than 15%. Following the above procedure again to identify the areas which exceed 25% in slope will yield the three categories of slope called for in the build-out analysis. Finding the areas of 25% slope or greater will be easier since these areas will always fall somewhere within those already identified as 15% or greater. If several categories of slope are to be identified, a lightly-drawn notation in the appropriate areas will avoid confusion later on.

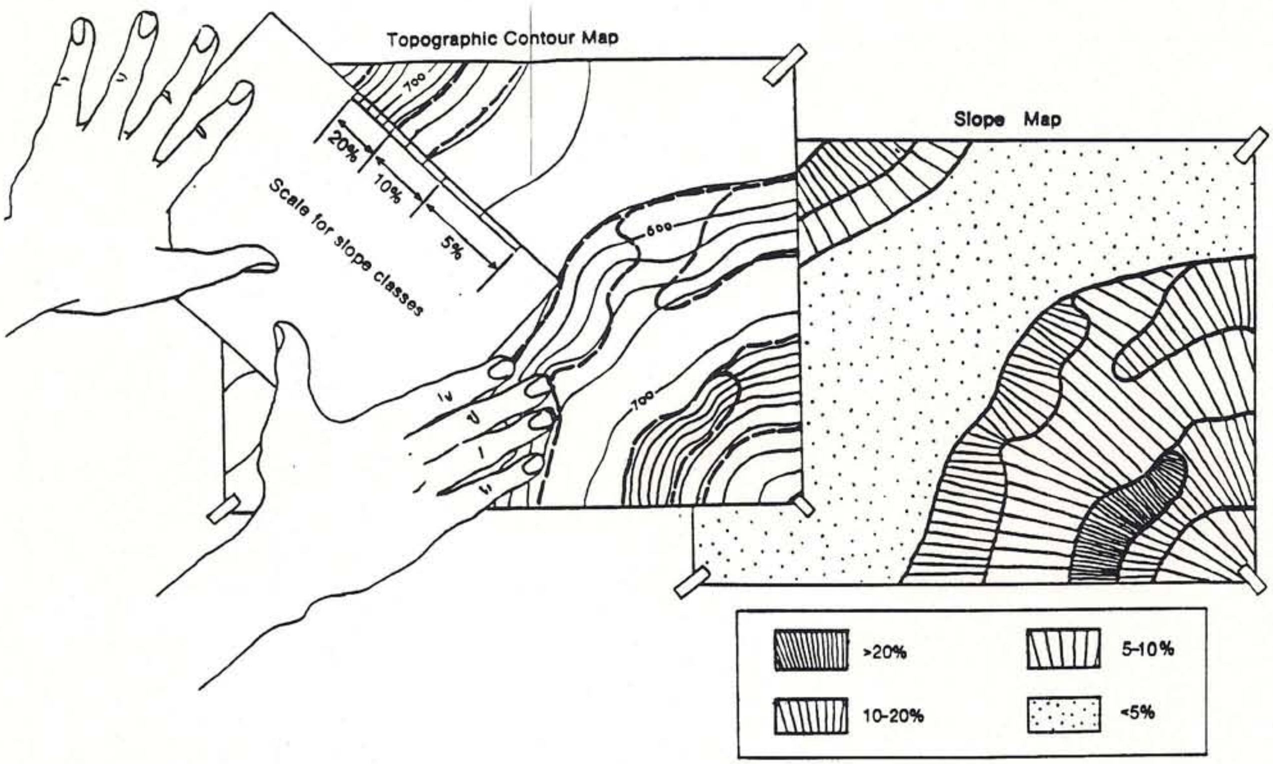

Fig. 11 Use of a scale to draw boundaries around areas of similar slope.

Developable Land

All lands not falling within one of the categories designated above are considered part of the town's net usable land area (NULA). It is identified on the map's legend as "developable land." Here is where future growth can occur, and, more importantly, here are the town's remaining developable open spaces, farmland, and forests. The spatial arrangement and overall extent of these parcels is the most revealing and useful information thus far generated in the build-out analysis.

At this stage, all the necessary mapped data has been transferred onto the drafting film. Check it carefully, erase any errors or smudges, and spray with a fixative.

Making the Print

A black and white, paper print can now be made from the drafting film. A diazo ("blue-print") machine with 36-inch wide, black-line, presentation paper produces very good copies (Fig. 3).

Copy-shops with large-format duplicating (xerox) machines can also produce the paper map. For best results have the copy made onto "vellum" rather than regular "xerox" paper to avoid the smudging of the black lines later on.

Coloring the Print

Almost everything within the municipal border line should be colored as to category (e.g., steep slopes, wetlands, etc.). Care should be taken, as mistakes at this point can ruin the paper print. However, in the event of an unacceptable, or "un-fixable" error, a new paper print can easily be reproduced from the drafting film.

Use the assorted marker pens (with broad and fine tips as needed) to color the areas within the various boundaries and the legend boxes as follows (Fig. 4):

developed land/road rights-of-way	black
surface waters	medium blue
wetlands	purple or pea-green
steep slopes	light red
public lands	white with black hatching
developable lands	yellow

The paper base map reveals much about the land surface and topography of the study area. In addition, the blackened areas, when viewed together, show the "pattern" of settlement area-wide. While concentrations of developed lands provide insight into past trends, large areas of yellow on the map (unconstrained and developable) are a window onto future possibilities. And the future is what a build-out analysis is all about.

CREATING THE OVERLAY

The next phase of the analysis, creation of an "overlay" for the base map, portrays in a conceptual way the potential spatial arrangement of new streets and structures that could be built at some point in the future (Fig. 12). That point is taken to be when all developable land has been consumed through subdivision into smaller lots, none of which may be further reduced in size under current zoning ordinances and subdivision control regulations. This is certainly not an implausible outcome, as many "old-growth" communities in metropolitan regions will attest.

Procedure

The overlay material is a clear polyester film, not to be confused with "acetate" which tears easily. Cut a sheet large enough to cover the entire base map and, with it as a template, transcribe the municipal boundary onto the polyester using a drafting pen, marker, or pressure-sensitive tape.

Next, looking through to the base map, but working on the polyester, add one additional line to the legend column. This should consist of another outlined box, a space, and the title POTENTIAL NEW DEVELOPMENT. This title should be created with the same medium-sized, press-on letters that were used for the rest of the legend. This part of the legend will only be visible when the overlay is in place.

Use a bright red marker or a drafting pen with red india ink to draw new streets and structures onto the polyester over parts of the base map that are yellow. The goal is to show full development on these lands, given the constraints of the current regulatory framework. The density and arrangement of this new development is

Fig. 12 Base map with build-out overlay.

dictated by the lot-size and road-frontage requirements found in the current zoning. As a town may have numerous zoned districts, these dimensional requirements will vary.

Another variable which influences lot size is slope. If three categories of slope were identified earlier, three development densities should be assumed. On slopes of less than 15%, development density can be as indicated in the zoning; on areas of 15% to 25% slope, however, development density should be reduced, and may be represented at a lower density of twice the underlying lot-size requirement. Areas with slopes in excess of 25% would not be shown with new development (although they may actually be buildable at very low densities).

When adding in new roads, be sure not to exceed the length limits for cul-de-sacs (dead-end streets), as specified in the local subdivision control law. Also, be aware that new streets, (under subdivision law) generally have an upper limit on gradient: slopes in excess of 10% are often prohibited. Use of the USGS topographic map, with its contour lines, may help alleviate this problem when laying out street patterns. Whenever possible, streets should run parallel to contour lines (or cross them gradually) in order to minimize costly blasting, cutting, and filling. Wetlands also must be factored in, and should be separated from new structures and roads by at least a 100 foot buffer area.

The form that these hypothetical streets take should roughly adhere to established patterns for grids, loops, cul-de-sacs, and "curvilinear" subdivision roads (Fig. 13). Also refer to realtor's road maps of nearby suburbanized towns to become familiar with these forms. Red dots, representing new structures, are placed along the newly drawn streets to indicate associated structures, whether commercial, residential, or industrial. Red dots should also be added to fill open "gaps" in development along existing roads as well. The proximity of one dot to another along a road must reflect applicable lot-size and frontage requirements in each zoning district. In commercially and industrially zoned districts some of the structures may be shown as larger squares or rectangles, representing supermarkets, shopping malls, and factories. Dots should be of a size and contrast such that they stand out when viewed from a distance. This is particularly important for display purposes at public meetings.

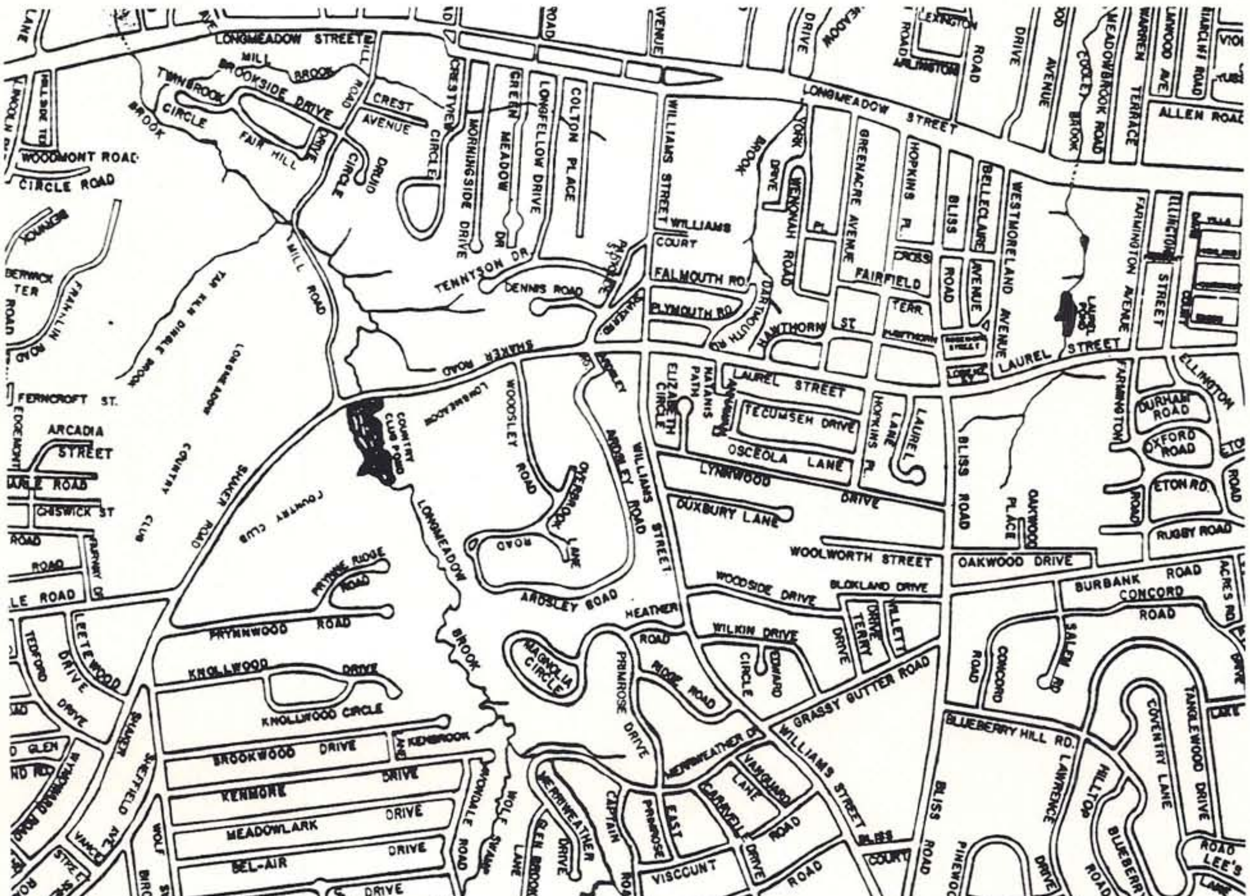

Fig. 13 Street map illustrating the pattern of new roadways upon a landscape without severe slope constraints.

Use of a property-parcel map (assessor's map) can add to the authenticity of the projected build-out pattern. In most situations properties are developed individually, without prior consolidation of adjacent parcels. Reference to the parcel map can help to "scale" small or large subdivisions in accordance with the size of each available land holding. However, such maps are not typically available at a scale useful to build-out projects. If that is the case, at least consult the maps to gain a better idea of the range of typical parcel sizes and shapes.

Without such a "reality check," one has no idea of the actual property boundaries, and can only scale the individual developments in a general fashion. As a guide, refer to some newly-built development configurations. When laying out possible new tract-style subdivisions, allow for a variety of sizes, but keep the limits within the already established precedents for the town.

In towns where a total build-out is not likely for 50 to 100 years, presentation of a completely developed overlay can lessen its credibility. In such cases, it is recommended that the eventual consumption of all available lands be more realistically depicted with three, "staggered" overlay sheets. Each sheet will show approximately 15-20 years of growth. The first should depict the addition of structures where frontage is available along existing roadways. This is followed by an overlay showing the consumption of the larger parcels of more easily developed land through subdivision. Finally, lands constrained from conversion by natural or cultural factors are shown to be developed. This later category can include private "estates," remote parcels, slopes of 15% to 25%, and quasi-public holding such as Boy Scout camps.

The multiple-overlay approach is effective in showing how a progressive build-out could occur. As each successive overlay sheet is placed over the last, the spatial distribution of new streets and structures follows the sequential growth pattern commonly seen in towns that are now fully developed.

When some form and intensity of development has been depicted on all of the unconstrained land (yellow on the base map), the overlay is complete.

THE NUMERICAL ANALYSIS

While the base map and overlay provide a striking visual impact, a quantitative expression of a study area's build-out potential can be just as revealing. Most of the information needed to complete this phase has already been determined on the base map through the process used to establish "developable lands" (NULA). These lands, rendered in yellow on the map, are now further assessed for their "carrying capacities" under current zoning. The entire numerical analysis can then be summarized on a single sheet of paper as shown in Figure 14.

Measurement of Area

The initial phase of the numerical analysis will quantify the areas delineated on the base map. First, a total acreage figure should be obtained from town records. Then, the mapped areas of public lands, developed lands, steepest slopes, wetlands, and surface waters are measured to determine their respective areas in acres. A computerized Geographic Information System (GIS) can make easy work of this, but, without such technology, other, time honored, but more time consuming methodologies can be employed. Planimetry, or alternatively the use of a dot-grid, are two common approaches. Planimetry is the more accurate of the two, but the instrument itself is tricky to use and expensive to purchase (may be borrowed from a geography department or local surveyor or engineer). A dot-grid is easier to use, inexpensive to purchase, and, if necessary, can be made from drafting materials already in hand.

WEST STOCKBRIDGE BUILD-OUT ANALYSIS*

11,738	TOTAL ACRES
- 34	PUBLIC LANDS
- 990	DEVELOPED LANDS
- 215	EXISTING ROADS
-3,075	SLOPES >25%
-1,186	WETLANDS
- 124	SURFACE WATERS
6,114	DEVELOPABLE ACRES (52%)
- 306	NEW ROADS (5%)
- 581	REQUIRED OPEN SPACE (10%)
5,227	SUBDIVIDABLE ACRES

TOTAL NEW UNITS

150	IN 0.5 ACRE ZONES
518	IN 1.0 ACRE ZONES
1,561	IN 3.0 ACRE ZONES
2,229	TOTAL

TOTAL NEW RESIDENTS

5,750 (AT CURRENT 2.58 RESIDENTS PER UNIT)

COMPARISON

	PRESENT	BUILT-OUT	CHANGE
DEVELOPABLE LAND	52%	0%	-100%
TOTAL UNITS	552	2,781	+403%
TOTAL RESIDENTS	1425	7,175	+403%

* Based upon information available in 1985.

Fig. 14 Numerical analysis summary sheet.

The dot-grid consists of nothing more than a clear sheet of polyester with an outlined pattern of square boxes (usually one inch square) in which there are regularly spaced black dots (usually 25 of them). Each dot represents 0.04 (1/25) of the area within the box. Knowing the scale of the map in question enables one to use the dot-grid to measure area.

For example, for a map with an specific scale of 1 inch = 1,000 feet, a one square inch box would contain 1,000,000 sq. ft. (1,000 ft. * 1,000 ft.). Since there are 43,560 sq. ft. in one acre, the box contains 22.96 acres (1,000,000 sq. ft./43,560 sq. ft./acre). Therefore, every dot in the box accounts for 0.9184 acres (0.04 * 22.96 acres). When the clear dot-grid is placed over the base map, areas within boundaries are determined by simply counting up dots that fall within (or mostly within) those boundaries (Fig. 15). Those falling directly on the border-line can be counted as one-half of a dot. A hand-held "clicker", with analog readout similar to an automobiles odometer, can make quick work out of counting the numerous dots.

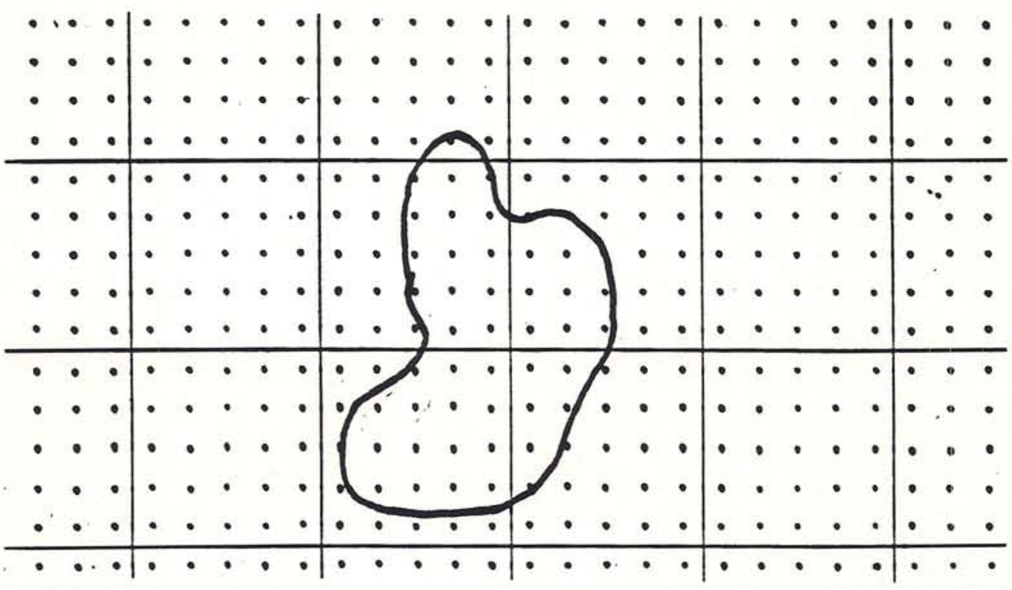

Fig. 15 Use of the dot-grid to measure area (45 dots fall within this bounded area).

A determination for areas within the existing road right-of-ways should also be made. To do this, multiply the linear length of all existing town roads (obtain figure from town records or by measurement) by the town's required right-of-way to obtain a figure in square feet, which is then converted to acres.

Example

Problem:

Find the acreage of constrained land along 54 miles of existing roadway in a town with a 50 foot road right-of-way.

Solution:

Convert 54 miles to feet:

54 miles * 5,280 ft./mile = 285,120 ft.

Multiply the width of road right-of-way by the length of the town's roadway:

50 ft. * 285,120 ft. = 14,256,000 sq. ft.

Convert square feet to acres:

14,256,000 sq. ft. * 1 acre/43,560 sq. ft.

= 327.3 acres

Result:

Existing road rights-of-way account for 327.3 acres of land.

Developable Acres

Subtracting all constrained areas from the town's total area yields DEVELOPABLE ACRES (in theory, what is in yellow on the map). This provides an interesting perspective into just how "open" a town really is - especially when expressed as a percentage. By using an overlay of the town's zoning-districts map, the amount of developable land in each use or density zone (e.g., Rural Residential/80,000 sq. ft., or Commercial/20,000 sq. ft.) can also be measured.

Developable acres can be further reduced by subtracting out any acreage consumed in the course of development by new roads and their rights-of-way, and by any dedicated open space required under subdivision control. These amounts should be determined for each use/density zone. For example, if the existing requirements for road-frontage, rights-of-way, and open-space set-asides in subdivisions are known, the reduction of developable land within any use or density district can be calculated.

The required open space should be factored out first by reducing developable land by whatever percentage is required for open space under the subdivision control law for the town. Next, calculate the percentage of the remaining developable land that must be portioned for road rights-of-way to access the units that could potentially be built in that use or density district. To determine this figure, calculate the amount of road right-of-way for each individual, minimally-sized lot in that particular district. For example, for an 80,000 sq. ft. lot, with 250 feet of required frontage, and in a town with a 50 foot road right of way (Fig. 16), the square-footage of the right-of-way would be:

25 ft. * 250 ft. = 6,250 sq. ft.

The total area of road right-of-way and lot would then be:

6,250 sq. ft. + 80,000 sq, ft. = 86,250 sq. ft.

Therefore, the portion of developable land in that particular district that will be dedicated to road right-of-way is:

6,250/86,250 * 100 = 7.25%.

Accordingly, the remaining developable land should now be reduced by 7.25%. This procedure should be followed for each separate district using the appropriate lot-size, frontage, and right-of-way requirements.

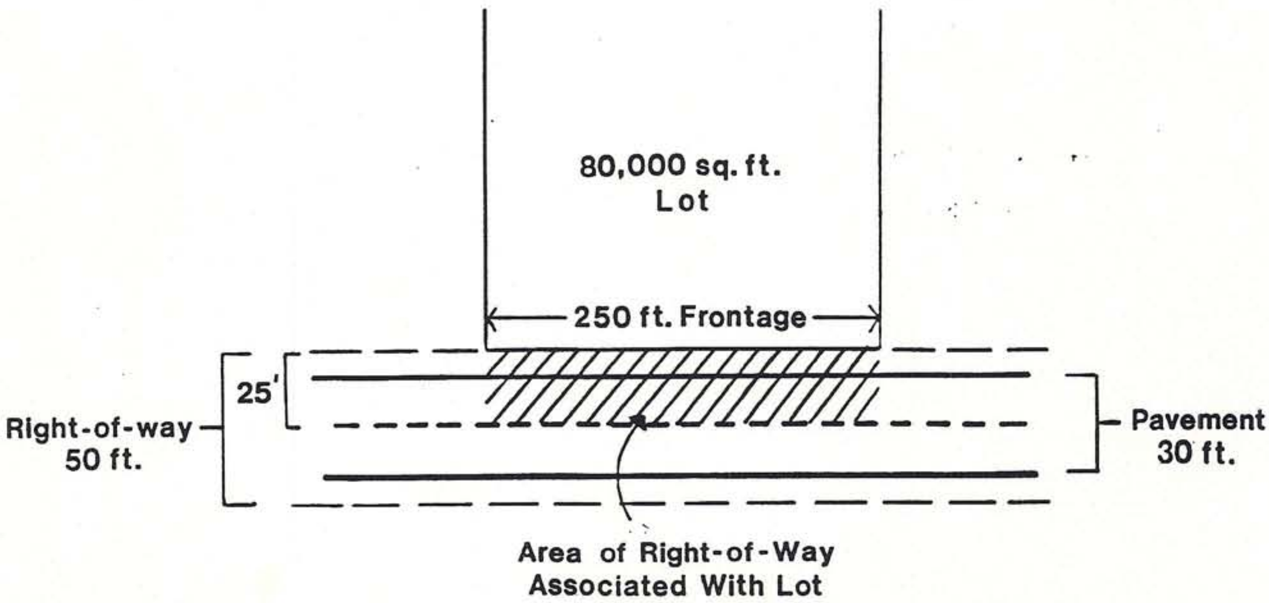

Fig. 16 Determination of the area within a road right-of-way.

Subdividable Acres

What remains is called SUBDIVIDABLE ACRES. This is the land area that can now go into privately held residential, commercial, and industrial lots. For the purposes of most build-out analyses it will be necessary to calculate only the number of new residential units which can be accommodated in each of the zoning districts. In large, undeveloped commercial and industrial districts where residential development is permitted as well, a simple assumption can be made that half the district will be developed for residential use. If, however, if these areas are totally unsuitable for residential development, and it is unlikely to occur in those locations, the districts in question can be discounted from any further calculations.

Housing and Population Analysis

At this stage, having figures for subdividable acres in each district will enable a quick calculation of potential new housing units by district. To do this, divide the total subdividable acreage by the underlying residential lot-size requirement. Adding up all the applicable districts will reveal TOTAL NEW UNITS.

Total new units may then be converted to TOTAL NEW RESIDENTS by multiplying by the state standard for household size per newly constructed unit, or by a more precise, local multiplier if available. (Derivation of this multiplier results from a division of the current population figure by the number of existing housing units.)

In addition, state or local multipliers can be further applied to yield that portion of the new population which will likely include NEW SCHOOL-AGE CHILDREN. This figure can be particularly enlightening in view of the fact that education accounts for the largest share of a municipal budget.

Finally, a comparison table may be generated to illustrate the differences between current conditions and those at build-out. These changes can be expressed both as raw values and as percentages. Parameters such as DEVELOPABLE LAND, TOTAL UNITS, TOTAL RESIDENTS, and SCHOOL-AGE CHILDREN should be included in the table (Fig. 14).

PRESENTATION OF THE GRAPHIC AND NUMERICAL ANALYSES

Presentation of the Build-Out Map

For ease of handling and protection, the colored-up base map should be mounted on some form of hard backing. A professionally-done dry mounting is best. The map will then be free-standing.

The polyester overlay(s) can be attached either permanently or temporarily to the top of the base map. The overlay(s) should be positioned to be easily brought down over the base map to illustrate the impact of the possible new development on the town's open lands. Care must be taken to ensure that the border lines of both base map and overlay are properly aligned.

When presenting these materials at a public hearing or planning board meeting it is important to spend some time discussing the base map before introducing the overlay(s). Explain what each of the colored areas represents, along with some of the sources, methodologies, and assumptions that went into their delineation. Emphasize the extent of the available lands for development, as that may be quite a revelation for some in the audience.

The presentation of the overlay should be preceded by an explanation that it is a depiction of a possible outcome under current zoning by-laws and subdivision controls. Once the overlay is in position, quickly explain that the red lines and dots represent a conceptual depiction of the town once its current zoning is fully implemented. Some time should then be allowed for the audience to fully absorb this vision of their town. An opportunity for questions and discussions should follow.

Presentation of the Numerical Analysis

The information on the one-page numerical analysis summary sheet should be xeroxed as a hand-out for all in attendance. In addition, a larger version (3 ft. by 5 ft.), lettered on white presentation stock, can be displayed next to the map itself. While the audience follows along on their copies, methodically go through the sequence of steps that generated the values in the numeric analysis. Be sure to point out the relationship between the map and the numbers that were generated from it.

Finish the presentation with the comparison table, emphasizing the many-fold changes possible in both the population and landscape of the town. You may wish to go back to the map once more, showing again how much "open" land there really is, and how those areas could eventually be consumed.

RECOMMENDATIONS FOR USE

The build-out analysis itself will not solve any problems - just point up the current situation. But, as such, the process and the final presentation of the results can serve as a catalyst for change in a community. A well done and skillfully presented build-out analysis is perhaps the single most effective tool to inform residents and officials of the ultimate consequences of not revising their present land-use regulations. Zoning that does not further the public good, as perceived by a town's residents, (e.g., retention of rural atmosphere, open space, recreational lands, aquifer-recharge capacity, etc.) should be examined in greater detail. A build-out analysis can "galvanize" citizens into taking the first steps in this direction. Aa a popular bumper-sticker says - "When the people lead, the leaders will follow."

Professional planners and those who serve on town boards that regulate and influence development may already be acutely aware of the inadequacy of existing local ordinances. However, that awareness generally does not extend beyond these few "insiders." A series of public forums to discuss these growth-management issues and the implications of the build-out analysis will naturally lead to an examination of more appropriate regulatory mechanisms - the kinds of planning tools and techniques that will both accommodate new growth and ensure the retention of open-space resources. The reaction to a build-out analysis can become a call for both action and more creative local planning.

Other, more innovative and flexible planning tools may be introduced and assessed for their applicability to a town's particular set of opportunities and problems. If open, working landscapes are integral to a town's character, then options such as open-space zoning (optional, or mandatory in certain areas), the purchase of conservation easements and development rights, the transfer of development rights, or agricultural-incentive zoning should be considered. If scenic roads are to retain the characteristics which make them so special, then measures such as site-plan approval, flexible road-frontage requirements, and scenic highway district standards are appropriate. In small, rapidly growing municipalities, demands for services, infrastructure, and education can easily exceed yearly budgets. In these situations, some growth-rate control can be achieved through phased growth, development scheduling, and building permit cap ordinances. Finally, where new or continuing land conversion threatens to turn country roads into unsightly commercial "strips," the adoption of commercial site-plan approval, curb-cut limits, large-commercial or commercial "cluster" zoning, village-commercial in-fill provisions, architectural design guidelines, and signage standards can be positive steps.

FURTHER INFORMATION

The Center for Rural Massachusetts has an extensive selection of publications and video-tapes available on a wide range of growth-management/creative-design topics. A publications list can be obtained by writing:

The Center for Rural Massachusetts
Department of Landscape Architecture and Regional Planning
Hills North
University of Massachusetts
Amherst, MA 01003
(413) 545-0153

In addition, the Center for Rural Massachusetts' award-winning publication - Dealing With Change in the Connecticut River Valley: A Design Manual for Conservation and Development is available through:

Publishers' Business Service (PBS)
Post Office Box 447
Brookline Village, MA 02147
(800) 848-7236