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ABSTRACT

Title of Thesis:	HOW HAS THE EVOLUTION OF PAVED ROAD SYSTEMS IMPACTED RURAL HISTORIC DISTRICTS? WATERFORD VIRGINIA: CASE STUDY
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One of the birthmarks of civilization, roads have played a pivotal role in influencing the relationships between people and their environment. This thesis investigates one of those relationships: the evolution of paved roads and their effects upon the fabric of rural historic districts.

It begins with a brief history of our transportation systems, and proceeds to consider their roles in shaping our society and the country's development. It traces the evolution of our nation's roads from their beginnings as pathways followed by Native

Americans, to the highways of our present autocentric world. Focused on the evolution of roads that traverse the rural regions of Virginia through what are now rural historic districts, it investigates the issues surrounding their financing and construction during the Great Depression, when limited funds and engineering expertise fashioned the methods used for their improvement.

The thesis establishes that the roads of Loudoun County's rural historic districts have been paved repeatedly, without the benefit of a comprehensive road drainage maintenance and management plan, and that successive layers of paving have raised road grades to heights that now impact the natural and constructed environments of these historic districts. More specifically, the failure to provide and maintain proper drainage has created environments that accelerate deterioration of building materials, and in some cases has led directly to structural failures. Improper drainage also has expanded the dispersion of water with damaging effects to the landscape. These consequences have skewed understanding of the districts' evolution, their historic resources and interpretation of the characteristics that warranted historic designation. The thesis concludes with recommendations for procedural and substantive standards for recovering and retaining the qualities that contribute to district integrity. Implementation of these recommendations would accomplish both short- and long-term goals for returning and maintaining district roadways to a condition that protects and enhances the qualities that contribute to district integrity and significance.

HOW HAS THE EVOLUTION OF PAVED ROAD SYSTEMS IMPACTED RURAL HISTORIC DISTRICTS?

WATERFORD VIRGINIA: CASE STUDY

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Thesis submitted to the Faculty of Goucher College in partial fulfillment of the requirements for the degree of Master of Arts in Historic Preservation

2004

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To Antonia,

without whose patience and encouragement

this thesis never would have happened.

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CHAPTER I
THE ROLE OF ROADS IN SHAPING SOCIETY AND ECONOMIC DEVELOPMENT OF THE UNITED STATES

Man's long journey from prehistory toward civilization began along the paths and trails forged by nomads herding animals. As agriculture and the domestication of animals replaced hunting and gathering as the main means of existence, changes occurred in the way people lived, their social order and the divisions of labor within their communities. This agricultural evolution enabled people to live in more or less permanent settlements, allowing the elements of civilization to take root. A fundamental component of these emerging cultures were the paths, trails and ways they established from hearth to field.

The Path To Civilization

Long before the rise of expanding cultures and acquisitive empires, the edges of the early civilized world were slowly being pushed back by the needs of growing settlements. Harvesting of forests for timber and firewood also produced arable land and pastures needed for the settlements' growing populations. Beyond their perimeters lay trackless reaches of wilderness where there were no paths, bridges, or established ways through the terrain. The need for overland passage had yet to arrive among these early settlements and was somewhat inhibited by insecurity, superstition and fear of the unknown beyond their fields. The settled order of their communities offered a modicum

of security in contrast to the perceived chaos of the wilderness beyond the edges of their settlements.

For thousands of years the roots of western civilization developed along the coastline of the Mediterranean Sea. The sea was the main thoroughfare for cultures to expand beyond their borders, allowing direct, unobstructed passage for trade, exploration and influence, while also providing a conduit for communication and the dissemination of knowledge. Though, incrementally, the success of sea-based commerce permitted early settlements to evolve into cities, states and nations, the limits of early western civilization's expansion were still essentially concentrated along the coastline of the Mediterranean.

Early Road Systems

The Minoans on the Mediterranean island of Crete were the earliest culture to successfully develop an engineered road system. "Minoan roads still in existence seem almost as good today as when they were built four thousand years ago"[1] during the Bronze Age. The Persians, Chinese and Greeks all had developed long distance trade routes, but it was the Romans who put their signature on the defining elements of long distance roads for commerce and travel, which are still used today. Construction of the first purposely built long distance highway, the Appian Way, began in Rome in 312 BC. Reaching the port city of Brindisi in 190 BC, it literally paved the way for the expansion of the Roman Empire and set the standard for road construction for the next two thousand years. There is a factual basis for the adage, "all roads lead to Rome": their roads radiated from Rome to the far reaches of the empire, stretching throughout Europe, Asia Minor,

Africa and as far away as Great Britain. When the Roman Empire collapsed, civilization fell into the Dark Ages and road building returned to mere pathways for maintaining communication and control of the local realms.

The first resurgence of national road systems to occur after the fractious Middle Ages appeared in France during the middle of the eighteenth century. By the first decade of the nineteenth century, France had built over 25,000 miles of roads, including the first roads through the Alps since the Romans. Meanwhile, in Great Britain, the first substantial refinements of paving in two thousand years were being developed. As nations achieved the financial means and political stability to implement national plans for improvement, the infrastructure necessary for long distance commerce and travel re-emerged.

Settlement Of North America

When the first settlers to arrive in North America reached the shores of Virginia and New England during the first decades of the seventeenth century, they were confronted with a vast, sparsely populated, unsettled wilderness. None of those familiar elements of civilization they had left behind existed in this New World. Their thoughts of finding wealth and riches were quickly abandoned when the harsh realities of this unfamiliar wilderness redirected their energies towards survival. Though these settlements evolved in different ways, shapes and geographic regions, the fundamental tasks of building shelters, clearing land and planting crops were typical to all. Though often overlooked, one of the fundamental elements of these settlements was the footpaths people walked daily, which became the borders and boundaries between their fields,

garden plots, dwellings and the edges of the wilderness. Beyond their settlements lay expanses of uncharted territory where there were no roads. Roads essentially evolved from use, created by a need to go from one place to another. However, the only passageways through this unsettled wilderness were those made over the centuries by the movement of herding animals and native North Americans following the easiest gradients between water and food sources during their seasonal migrations.

Footpaths, Trails and Roads

Reminiscent of earlier emerging cultures along the Mediterranean Sea some two thousand years before, the initial colonial settlements of the United States developed along the navigable rivers and coastal seaports of the east coast, where water passage was the easiest way the settlements could trade, communicate and travel. Later, as settlement pushed inland "away from the seaports a network of roads grew slowly in the traditional manner—from animal trail to man trail to widening for passage of beast of burden and small vehicles."[2] In little over one hundred years, the population of the colonies had grown to nearly two million people. The majority were farmers, who traversed these trails in search of suitable arable land beyond the coastline. Their continual passage along these ways helped establish many of our present transportation corridors.

Along the pathways they traveled, small settlements sprouted at native crossroads, beside springs and around newly constructed mills. As the pace of expansion increased, fueled by the ever-increasing influx of immigrants, Native American Indian tribes were pushed further west. Simultaneously, new settlements continued to be established along the coastline and navigable rivers of America. From the entire eastern seaboard, settlers

were spreading westward. The roads connecting their settlements were marginally improved as the broadening agrarian community brought more of the surrounding land under cultivation, but the westward spread of the burgeoning population created needs well beyond the capability of these self-reliant settlers and their marginal roads. Although within every successful colony the need to improve inland roadways for commerce became evident, the governing authorities provided little more than authorization to the local jurisdictions to require their abutters to maintain the roads.

Emerging Infrastructure Needs

The need for infrastructures supporting the flourishing regional economies of the colonies arose in response to the proliferation of economic opportunities of the regions. Essential to the continued success of this expanding agricultural economy was an efficient means of transporting products to the marketplace. Though early roads had negligible effects upon their environments, the construction of more permanent roads led to much greater impacts. For each new means of transportation introduced into the landscape, the surrounding physical environment was altered to accommodate its installation. Accompanying these environmental changes were changes to the cultural environment of the area as well. This cycle continues to this day with every new or improved addition to our transportation systems.

Early Colonial Roads

The early roads of the colonies were nothing more than local pathways and trails that satisfied the essential needs of passage. They were located along the natural contours and passageways of the land, though not necessarily along the most direct routes.

Significantly, they were built lightly upon the land, with considerable attention given to the immediate topography, the location of creeks and streams and the ability of the soil to bear passage. These paths of least resistance were the natural choices for early roads, generally the least expensive to build and at the same time the most environmentally benign.

The often-heard adage that "all roads are local" may well be attributed to how the development and responsibility for roads during the early settlement of this country were defined and financed. Within the Commonwealth of Virginia in 1657-58, the Virginia Assembly "vested the various county courts with full responsibility for the dedication, clearing and maintenance of all roads, bridges and 'general ways' from county to county and to and from the churches. The county courts were also instructed to annually appoint 'surveyors of highwaies,' who in turn, with the assistance of the 'hands' living along the roads, would be responsible for maintaining all of the public roads and bridges."[3] The roads that were built during this period were financed by the labors of those abutting their edges. Understandably, their condition and growth were slow to improve until the needs of their abutters and the surrounding populace truly required them. When agriculture production reached levels beyond the consumption needs of their communities, marginal roads were improved and extended in an effort to expand markets to more distant areas, the coastal seaports, and beyond.

Turnpikes

Turnpikes were the first major steps toward the development of an overland regional transportation network in the United States. Turnpikes were purposely built

roads that connected distant areas of commerce in a more efficient manner than the early meandering colonial roads. Around the turn of the nineteenth century, in response to the necessity to improve the corridors of transport for commerce and travel, turnpikes emerged. States began chartering turnpike corporations. "Such entities appeared as the only way individual investors might pool their resources and so gather the immense capital to build roads."[4] Need once again was the driving force behind this next step in the development of our country's transportation infrastructure.

America's population had risen to over five million people when the nineteenth century began. With the majority of the population (94%) living on farms and realizing their livelihood through agriculture, the need for internal road improvements in the country was apparent.[5] Yet, because the fledgling republic's financial support for internal road improvements was still almost nonexistent, the private sector stepped in to provide the needed service. Groups of investors began purchasing rights-of-ways, clearing the land, surfacing the roads and charging tolls to earn returns on their investments for providing rights of passage. Their initial success inaugurated a turnpike-building boom that saw thousands of miles of highways built throughout the republic. They connected distant inland villages and towns with direct routes for the exchange of goods among the growing network of towns and cities along the navigable rivers and coastline. While local public roads followed "favorable landforms and topographical conditions,"[6] turnpikes were laid out and constructed as straight as possible regardless of gradients to efficiently serve regional commerce and minimize land costs. They were commercial endeavors, privately built, owned and operated with the hope of financial gain from the collection of toll fees. Tolls were structured according to two principles: the value of the cargo and the

damage its passage might inflict upon the road surface. "A pedestrian paid very little and a horseback rider little more...whereas carriages and wagons paid proportionately more because of the value of the conveyance and its cargo,"[7] and because it took a greater physical "toll" on the road.

One of the first major turnpikes in the United States, The Little River Turnpike in Virginia, was a successful enterprise. It was initially authorized in 1785,when the state appointed nine commissioners "to erect, or cause to be set up and erected, one or more gates or turnpikes across the roads, or any of them, leading into the town of Alexandria."[8] Completed in 1809, it connected Alexandria with the Aldie Mill, the largest manufactory in Loudoun County at the time. Besides being one of the first toll roads in the country, it was also one of the first to make a profit; tolls were taken every ten miles, ranging from three cents for a horseback rider to twenty-five cents and more for a carriage and heavy wagons. It operated as a toll road for nearly a century. Today, portions of its alignment are known as John Mosby Highway and U. S. Route 50.[9]

Though there were profitable turnpike companies, "the majority, often hastily conceived and with little realistic consideration of traffic demand, were failures,"[10] with insufficient revenue for repairs and maintenance and plagued by greedy shareholders, their conditions deteriorated to the point where many were taken over by the states. Concurrently, canal builders and railroad companies were making inroads along the nation's transportation corridors, striking a damaging blow to turnpikes' economic viability. The demise of so many turnpike companies essentially brought regional road building to a halt. Though turnpikes were one of the first elements of regional transportation systems to develop in the United States, their fate remained uncertain for

nearly one hundred years. Then, at the turn of the twentieth century, our renewed needs for regional roads resurrected them. Not surprisingly, many of these early turnpike routes are the same alignments our highways follow today. But what is surprising and purely coincidental is the Dulles Greenway, which opened in 1995. The first privately built toll road in Virginia in nearly two hundred years and it parallels within miles the Little River Turnpike one of the very first private turnpikes.

Canals

Inland canals, the next stage in the evolution of regional transportation systems, were being constructed during the same period that enthusiasm for turnpikes was waning. Water passage was still recognized as the most inexpensive and efficient method of transporting goods between their sources and consumers. During the early years of the nineteenth century, canal advocates promoted the benefits of water transportation, arguing that a canal system of "cheap and regional transport will draw forth the ponderous riches of the earth, and circulate our minerals for the benefit of the whole community. It will float the products of the forests of the western states to the seacoast, returning the necessaries and luxuries from foreign nations to our interior. It will encourage manufactures by a cheap conveyance of raw materials; promote and refine agriculture, increase population and advance civilization throughout the whole range of the country."[11]

The most successful canal of the era, the Erie Canal, transformed the State of New York forever. Its construction, started in 1817, covered 363 miles, connecting Albany to Lake Erie at a cost of $7.6 million, with eighty-one locks along its path that enabled it to

transport boats over the 700 foot difference in elevation between its termini. The canal's presence created urban centers along its path and made New York City, which is connected to the canal by the Hudson River, the commercial center of the east coast by 1825 when it was completed. "Within nine years tolls had paid off the cost and interest on the financing. Travel between New York and Buffalo dropped from 20 days to eight, and the freight rates from $100.00 to $10.00 a ton."[12]

While the success of the Erie Canal encouraged construction of many other canals throughout the states, the same optimistic enthusiasm and poor planning that befell many turnpike builders often plagued canal builders. The Chesapeake and Ohio (C&O) Canal, built along the northern shoreline of the Potomac River, was a victim of such planning. Envisioned as connecting the Potomac and Ohio Rivers, its major obstacle was the Allegheny Mountains, some 2,750 feet high. After twenty-two years of construction, the canal reached Cumberland, Maryland, where construction ceased considerably short of the Ohio River. Nevertheless, "By the 1870s the C&O had spawned a boisterous trade involving 500 canal boats and 4,000 mules, mostly hauling coal."[13] Even though the C&O Canal never reached the length envisioned by its backers, it was a contributing component of the regional economy. Although the flood of 1889 bankrupted the company, it was able to operate while in receivership until the flood of 1924 destroyed the canal beyond repair.

While the potential benefits of canal systems were easily understood, the building of such complicated projects over, around and through the landscape were massive undertakings requiring sophisticated yet scarce engineering skills and enormous amounts of money and labor to reshape the natural topography. The topographical obstacles and

flooding encountered along the towpaths of these canals were major determinants of their success or failure.

Expanding Infrastructure Needs

During the first half of the nineteenth century, the United States economy began a transition from regionally focused agrarian markets towards an industrial economy as the inventions and technology of the Industrial Revolution reached our shores. The Industrial Revolution had been progressing in England and Europe since the eighteenth century; by the time it reached the United States, its principles had taken hold. The harnessing of steam for power, the keystone of the Industrial Revolution, made possible the replacement of waterpower with steam power. Steam power's more flexible uses and applications, in turn precipitated the need for workers in urban centers and transportation hubs that gave further rise to cities as economic and political centers and contributed to the reshaping of society. Now people could not only make machines for producing goods but also make machines that could build the machinery for new industries. The Industrial Revolution would have far-reaching effects upon our culture that would transform our nation.

This emerging industrial economy's thirst for workers, raw materials, goods and services and their efficient transport challenged the capacities of our existing network of canals, river transport, turnpikes and local roads to keep pace with the rapid growth of our industrializing economy. In the 1830s the solution seemed apparent: railroads. The advent of railroads added a new layer to our internal transportation systems that would

prove capable of keeping cadence with our industrialization efforts well into the twentieth century and play an important part in the continual reshaping of our world.

Railroads

The appearance of railroads in the 1830s advanced the demise of canal building. Railroads were able to expand the transportation networks, connecting those areas well beyond the reach of the existing regional waterways, local roads, turnpikes and canals. The Industrial Revolution was just starting to get up a head of steam in the United States when the railroads first started connecting the country with a more economical and efficient means of transport. By 1869, just forty years after the first rail lines were laid, railroads stretched across the country, transporting the raw materials necessary to fuel the new industrial economy and the finished products to connect rural regions and industrial centers.

The concept of transporting cargo over fixed tracks had its beginning long before the advent of railroads. Ancient paved roads had grooves cut into them the width that a wagon's wheels track. The grooves helped keep the wagons and carts on the road through rough terrain, guided them around curves and permitted oncoming vehicles to pass safely. Turning the grooves into raised rails above the ground appeared much later when the idea of having a flange on the inner edge of the wheels was developed, allowing a vehicle to remain on the tracks.

However, raised tracks and flanged-wheeled carts pulled by horses could satisfy the needs of a growing commerce for only so long. The need for a more efficient source of motive power was fulfilled when steam was harnessed and refined into a practical

power generator. The steam-powered locomotive was one derivation of this new power source. Its development was a key factor in the Industrial Revolution's progress; economies were driven to new heights by the access to resources and markets railroads provided.

While canal companies tried to compete with the upstart railroad lines well into the 1840s, they were at a considerable disadvantage. Their quests to reach the land beyond the Appalachian Mountains were often plagued by the natural constraints of winter ice, spring floods, summer droughts, difficult topography and the economics of such enormous endeavors. Besides, their construction was so labor intensive they could not keep pace with the speed and efficiency with which rail tracks could be laid, nor were they able to compete with the economy and utility of the steam locomotive.

Competition between entities like the Baltimore and Ohio Railroad (B & O) and the C & O Canal provides an example of how the railroads contributed to the demise of canal building and came to dominate the corridors of commerce from the 1840s well into the twentieth century. The B & O Railroad began as a raised-rail horse-drawn tramway, coincidentally on the same day, July 4, 1828, as President John Quincy Adams ceremoniously broke ground for the C &O Canal.[14] The tramway was constructed of iron rails secured to wooden ties laid over a foundation of stone and gravel. Horses pulled the rail carts carrying freight and passengers along these tracks in the same manner that they pulled boats along the canals of the period. But that would all change in 1831 when, after reaching Frederick, Maryland, the B & O took the revolutionary step that would catapult the railroads towards dominance: they replaced their horse-drawn power with steam-generated locomotion. In 1848, twenty years after the first track was laid in Baltimore,

the B & O Railroad reached Ohio, tying the midwest to the mid-Atlantic seaboard for the first time by railroad, while the C & O Canal ceased construction before crossing the eastern continental divide.

This product of the Industrial Revolution succeeded in connecting rural regions with distant industrial centers at a prodigious rate. Starting from a mere twenty-three miles in 1830, the tracks grew to 2,808 miles by 1840, and stretched over 30,626 miles by 1860. Michigan had its first rail tracks in 1836 and rail lines were operating west of Chicago by 1848. An all-rail route connected Chicago to the east coast by 1853. By 1854, rail tracks reached the Mississippi River, crossed it two years later and arrived at the Missouri River in 1859.[15]

Throughout their buildup, railroads carried freight, passengers, and the mail. "Once established, the railroads proved so much more efficient than other means of travel...that they virtually took over transportation in the United States. By 1900 the country had 250,000 miles of railroad,"[16] replacing almost all other means of long distance travel and freight transport. Throughout this period of rapid growth, while most of the nation's roads idled away, the railroads were busy altering our perceptions of time, space and distance, introducing new technologies to society, assisting in the settlement of the west and transforming the country into a commercially cohesive nation.

Motor Vehicles

Although the railroads' dominance of our transportation networks would last well into the twentieth century, new, promising transportation technologies were appearing on the horizon that would eventually threaten their supremacy as the preferred means of

conveyance. Enterprising individuals had been grafting small steam engines, electric motors, and internal combustion engines to carriages and wagons that were appropriately called "horseless carriages." After years of experimentation and development, the internal combustion engine would become the norm for motorized vehicles. Motor vehicles were at first luxury items. As production capabilities were increased thanks to the advent of the assembly line in 1913, their costs went down proportionally. However, there was one element that inhibited their widespread use: the extremely poor condition of the streets and roads throughout most of the country.

An urban toy of leisure, the bicycle, inspired the first calls for improved roads. Bicycling had become a popular leisure activity in the 1890s. "Bicyclists in urban areas crowded onto the few paved streets and paths that existed...formed clubs and urged local officials to improve roads to support their leisure activity."[17] Initiating the "Good Roads" movement, they petitioned their state and local officials for all-weather hard-surfaced streets and roads.[18]

The same need for better roads was growing on the streets of our urban centers. Cities were being strangled by the congestion of horses, wagons and carriages. Though streetcars, trolleys and subways alleviated some of the congestion for awhile, the addition of trucks and automobiles to the mix compounded the problems of congestion and heightened the need for improved roads. By 1910, motor vehicle production grew to 500,000 registered vehicles in the United States.[19]

Rural regions fared even worse. Little had been done to improve or maintain their roads over the previous century while the railroads were providing for the needs of local commerce. But as trucks and automobiles began making inroads as a preferable means of

conducting business and travel, the shortcomings of the country's internal road system re-surfaced. Most rural roads had remained little more than dirt paths throughout the previous century, impassable after heavy rains or during winter thaws and prone at other times to raising choking clouds of dust that would cover everything with the grime stirred up by passage.

In 1893, the Federal government's first steps toward a national road policy were implemented when Congress established the United States Office of Road Inquiry within the Department of Agriculture, "to make inquires in regard to the system of road management throughout the United States."[20] Even though the Office accomplished little, its creation was recognition of the need for and a start toward the formulation of a national road policy. In 1905, the Office of Road Inquiry achieved a more permanent status with the establishment of the Office of Public Roads, later to be renamed the Bureau of Public Roads.

Federal aid to state highway programs appeared for the first time when the Federal Aid Road Act of 1916 was enacted. However, the many different state agendas, their financial capabilities and the actual needs of each state complicated an equitable implementation of the 1916 statute. Spurred on by the rising needs of farmers for all-weather farm-to-market roads and calls for long distance roads for interstate commerce, a more comprehensive federal road aid policy was developed after the First World War by the Federal Highway Act of 1921. That law provided an acceptable formula for authorization, financing and oversight of new road construction and improvements to existing roads for the states.

The need for new and better roads never ceased. Motor vehicle registrations increased from one half million in 1910[21] to nine million by 1920[22] and twenty-six million in 1930.[23] The population continued to grow and expand outward from urban centers, but road building and paving simply could not keep pace. Even in the 1940s many roads remained unpaved in the United States at the same time the concept of an Interstate Highway System was unfolding.

The United States was settled and grew into a nation during a period of enormous change in the western world. Technological advances were reshaping economies, cultures and environments. While the sense that one technological discovery leads to another and another would seem logical, in actuality they evolved concurrently on many levels. Our transportation systems unfolded in just such a manner, without order and at times simultaneously through many forms of development as the nation traveled from a period of dirt paths to modern highways.

The pathways of early settlements evolved into roads and highways contemporaneously with the expanding needs generated by our nation's growth. The first inland roads stretched outward from the colonies' established seaports following the paths of settlement. As the country transitioned from an agrarian society to an urban industrial society, private turnpike companies, canals and then railroads further improved the transportation corridors for bringing farm products to market and for general commerce and travel. Throughout the nineteenth century, these closed systems fulfilled the country's transportation needs to varied degrees, but their configuration imposed limits on mobility because of their fixed schedules, destinations and dedicated infrastructure.

Roads, on the other hand, have always been about individual, independent mobility. Even though they remained largely unimproved until the twentieth century, they are inherently more capable than other transportation infrastructure forms of going to a specific destination. During the last decades of the nineteenth century, numerous technological developments and advancements were converging toward what would become the next addition to our modes of transportation: motorized vehicles. Within a few decades, trucks and automobiles would revolutionize our transportation networks and alter American culture and environments forever.

Throughout our paving and road building history, researchers and engineers have worked toward developing methods of improving materials, construction methods and safety, while paying less attention to the impacts roads have on the environment, our historical landscapes and buildings and the cultural heritage of our nation. How these methods and propensities have manifested themselves over the past century in our cities, towns and villages has yet to be reviewed comprehensively.

CHAPTER II
FROM PATHS TO HIGHWAYS

The paths of colonial America evolved into roads in the same manner as roads have developed throughout time. Like the concentric rings formed by raindrops falling on a pond, early colonial roads radiated inland from their settlements as they expanded the boundaries of their territories. The process by which early settlements became villages, then towns and some, cities, was intertwined in a confluence of geography, economic opportunity and population sizes. Their roads evolved in a similar tiered manner. Whether local or regional, their condition and rate of construction were greatly influenced by the immediate geographical conditions, the economic dimensions of the area and the needs of the surrounding populace. The story of road development in the United States begins in the oldest sections of our urban centers where these paths and ways from the water's edge first extended inland.

Urban Transportation

"Historians have characterized the preindustrial city of the early nineteenth century as the pedestrian or walking city. Business and commercial enterprises clustered in central areas, usually near the waterfront."[24] The inhabitants of these cities, businessmen and workers alike, lived within walking distance of their workplaces. The distance one could walk within a reasonable amount of time essentially defined the boundaries of the city. "As late as the 1850s, the built-up portions of large cities such as

Philadelphia, Boston and New York rarely spread beyond two miles from the city center."[25] It would take the urgency of rapid population growth and the changing needs of commerce brought on by industrialization to stimulate new modes of transportation and a rethinking of city street layouts, to transform the walking cities of the early nineteenth century into industrial centers.

The organic layout of "old towns," with their haphazard, narrow, winding, dirt roads quickly became inadequate in the face of industrialization. For cities to grow in a more logical way, new approaches were needed to facilitate mobility and accommodate the infrastructure necessary for their continued growth. In response, city roads began extending outward from central business districts, with cross streets laid out perpendicular to them, forming grid patterns that gradually grew into streets with hard surfaces and edges on a scale large enough to enhance the movement of both commerce and people.

The earliest mode of transportation to facilitate the expansion of cities was the horse-drawn omnibus. First appearing in the 1830s, omnibuses, for a fee, could carry one further than he could walk over the often-muddy dirt roads of the time, away from the congestion of the central business district, giving those who could afford bus fare the ability to live up to five miles from their places of employment. Thus were the cities' edges pushed measurably outward for the first time.

During the 1850s, another significant advancement in inner-city transportation appeared in the form of horse railways. The combination of horse-drawn power with rail tracks set in the streets was the first system to introduce a major transportation infrastructure component into the city fabric. Because these railways required a dedicated

foundation to support the rails and increased loads horse cars could carry, they transformed the network of city streets in important ways. First, they were instrumental in establishing a fixed network of interurban transportation routes in and out of the central business districts. Second, their paths preordained and encouraged where development along the cities' periphery would occur. As their networks expanded, they carried more people for lower fares, allowing a larger portion of the populace to enjoy the benefits of living outside the congested business districts. Along these corridors, the first significant expansion of cities and their road networks began.

Twenty years later, technological advances were on the verge of replacing horsepower with mechanical power. "Urban transportation technology developed slowly in the early nineteenth century, but a succession of new innovations tumbled off the drawing boards of inventors and engineers in the last quarter of the century."[26] Cable cars were the next translation of engineering advances applied to the mass transit systems of many cities. The infrastructure necessary for their operation required further upgrades to the streets they would travel. Cable cars were propelled along a continuously moving underground cable powered by a stationary mounted steam engine; the operator could start and stop the car by clamping onto the cable with a grip. While cable cars were an improvement over horse railways, moving more people at greater speed, their installed costs were high and the elaborate system of pulleys, idler arms and guides under the street needed frequent maintenance. Component failures often required the entire system to be shut down for repairs. Despite the high costs of their initial construction and maintenance, they were an improvement over the horse car rail lines, successfully servicing many major cities for almost two decades and continuing the transformation of

city streetscapes. Indeed, San Francisco's cable cars are in daily use today and are recognized as a symbol of that city.

Mass transit systems continued their evolution well into the last decades of the nineteenth century, accompanied by street improvements in support of these systems and the development that grew up around their rights of way. Cities were inclined to adopt those systems that held the most promise for increasing the capability of their transportation networks to satisfy the swelling needs of their residents and business enterprises. Trolley cars, the marriage of railways with newly refined electric motors, held such promise. "The first practical electric trolley was realized in 1888, moving over the streets of Richmond, Virginia, soon to become the dominant means of urban transportation in the American city."[27] Their sudden success motivated most horse car railways and cable car systems to convert to electric trolleys in the 1890s. "By 1900 there were over 30,000 cars running over more than 15,000 miles of track,"[28] in the United States. Powered by overhead electrical lines along the rights of way, the trolleys' increased speed and greater passenger miles continued the process of transforming the urban environment. However, the expansion of mass transit systems in many cities was approaching an impasse toward the end of the nineteenth century.

In many major metropolitan areas, the congestion and snarls of street traffic became overwhelming, especially to pedestrians. The Brooklyn Dodgers baseball team originally was known as the Trolleydodgers, named for people who nimbly jumped out of the trolleys' way. "Like horsecars and cable cars, the electric trolley had to compete with pedestrians and with other vehicles for space in city streets. Frequent traffic jams in congested downtown areas slowed the streetcars considerably. . . . engineers sought to

avoid street-level congestion by building rapid transit systems both above and below the ground."[29] Elevated railways, technology's initial response to the cities' need for a rapid mass transit system, began operating above the streets of New York City in the 1870s. Because subways' requisite infrastructure was so much more complicated, intensive and expensive to construct, it took many years to surmount logistical and financial obstacles before their construction commenced. In 1897, Boston inaugurated the first subway system in the United States. Elevated railways and subways were the last mass transit systems having an extensive infrastructure tied to their successful operation introduced into the fabric of major cities, bringing "to an end more than a half century of technological innovation in urban mass transit. In 1908, the year the Philadelphia subway was completed, Henry Ford brought out his first Model T automobile."[30] Though it could not be known at the time, the automobile was about to permanently rearrange the fabric of our spaces and lives.

Throughout the nineteenth century, the country's regional and urban transportation needs had been supplied by closed systems, controlled and operated by entrepreneurs and corporations that built and maintained their systems for profit from fees or tolls for freight or passage. The urban roads around these systems matured with them, both supporting and augmenting the expansion and improvement of cities, but rural outlying road networks languished, with few substantial road improvements initiated beyond the borders of urbanized areas. Though bicycle enthusiasts had spurred some interest for better roads in the last decades of the nineteenth century, it would be motor vehicles that made the need apparent.

Rural Transportation

There's a commonality to the beginning of most all roads, as they developed in response to the dynamics created by a settlement's needs. As the frontier was settled, the first roads to appear were those which turned inward, connecting farms with developing economic centers. As these rural centers grew into villages, milltowns and county seats, their road network also grew, first developing within and then spreading outward toward other villages, towns, and cities as the needs of their community and region grew.

Rural transportation had developed in a traditional manner while our nation's growth was driven by an agrarian economy. Then, during the last half of the nineteenth century, as the country shifted toward an industrial economy, the focus of our transportation network changed to tending this industrial economy. Though turnpikes, canals and railroads connected portions of the rural hinterland with the larger economies of urbanizing America, most of the backcountry roads went to pieces. Little money was devoted to road improvements or construction. Essentially, the web of local roads was left to the road abutters and the local populace to maintain and develop.

Excepting the turnpikes built by private corporations during the first quarter of the nineteenth century, rural road building and maintenance had always been carried out at the local government level. "Ever since colonial times, southerners had paid their local taxes by spending a day or so each year actually working—with whatever farm equipment was available—on the improvement of their communities' public roads. This practice spanned two centuries, and as late as 1912, every southern state used the method."[31] Understandably, local roads were not significantly improved until the need

was well established. As a result, road improvements were always behind in addressing the public's needs.

Regional And National Transportation

The oldest "interstate" or national roadway in the United States was the mail route that first connected Boston to New York City in 1673, later called the Boston Post Road and now US Route 1. Our earliest inland roads were those cut by armies through the wilderness to frontier outposts during the French and Indian War. Many of these military trails, in combination with the turnpikes of the early nineteenth century, created a number of east-west corridors that advanced the settlement of the midwest and beyond. By the time the French and Indian war ended in 1763, "the population in the British colonies along the seaboard had grown to nearly two million, whereas the French had almost no settlements."[32] Pioneers pushed westward along these same military trails to new frontiers after the British had finally defeated the French for possession of large portions of North America.

The first major long distance road funded with federal money, known as the National Road, was "proposed in 1784 by George Washington and Albert Gallatin, first financed by Congress in 1805 during Thomas Jefferson's administration."[33] The Act called for a road connecting Baltimore to the Ohio River. Its path incorporated the Cumberland Pike and parts of the same military trails from the French and Indian War, cut by British General Edward Braddock's army through western Maryland and southwestern Pennsylvania. Federal funding for the National Road, now U.S. Route 40, beginning in Cumberland, Maryland, was to traverse the midwest to St. Louis, Missouri,

but construction stopped at Vandalia, Illinois. Its funding quickly evaporated, while the states debated what role the government should have in national improvements. There was a long-simmering fear among many states that an all too powerful central government could wrench territorial control away from the states if a system of national roads were built. At the same time, the succession of turnpike, canal and railroad building projects dampened any further consideration of federal investment in a national road system. Neither the states nor the federal government had the ability or desire to invest in large scale public infrastructure improvements, especially while private corporations were already adequately providing for the country's transportation needs. Besides, long distance roads fell out of favor as a means of inland travel with the arrival of railways. The more efficient and economical railroads quickly took over the corridors of commerce and travel, essentially putting a halt to any government funded road building in the United States for decades.

Regional road building fared little better than rural roads throughout the nineteenth century, though a few states, recognizing that something needed to be done established bureaus that would eventually become their departments of transportation. Virginia was the first to enact major road improvement legislation in the United States, when in 1816 it created the first American State Board of Public Works. Headed by Colonel Loammi Baldwin, "the act provided for a corporate body with the power and funding to undertake public projects supervised by a principal engineer, or surveyor,"[34] but little was actually done to improve regional roads. Instead, their main focus was directed towards urban road surface improvements.

In the last decade of the nineteenth century, calls for better roads were being heard in the country, first initiated by "the League of American Wheelmen, an organization of bicyclists . . . [T] heir favorite pastime was bicycle touring; but when confronted with roads that were not hard-surfaced, and muddy, rutted, and ill maintained to match, bicycling was no pleasure."[35] They were joined in their lobbying efforts for better roads by progressive advocates of the "Country Life Movement" and populists pushing for economic reforms to benefit the agrarian economy threatened by changes brought by the country's rapid industrialization. Their "quest for good roads began as an effort to enhance rural life and stabilize the traditional values associated with farming,"[36] that merged into advocacy for better roads because of the social and economic opportunities their improvements would bring to rural communities. Collectively, their ardent campaign was known as the "Good Roads Movement," effectively influencing Congress to create a national highway commission in 1892 and the Office of Road Inquiry a year later.

Though the government acknowledged the need for a national road policy as early as 1893 with the establishment of the Office of Road Inquiry, the exponential growth in automobile ownership over the next two decades quickly laid bare how woefully inadequate the country's public roads were. "A nationwide road census in 1904 showed 2,151,570 miles of roads, of which only 7 percent were classified as 'improved' or surfaced with stone or gravel. The remaining 93 percent were dirt roads."[37]

When Henry Ford introduced the assembly line in 1913, the efficiency of automobile production accelerated drastically, allowing manufacturers to lower their prices, which resulted in more people owning automobiles. As automobiles quickly

became the preferred means of transportation, their increased numbers put enormous pressure on the federal and state governments to address the immediate need to improve the country's network of public roads. However, investment dollars gravitate toward the potential for gain, whereas road projects traditionally had offered little monetary gain from their construction, save for those who actually directed their building and for the property values of the abutters along the rights of way. The formation of totally new federal and state government departments and enabling legislation were needed to address the nation's explosive need for better roads.

To underscore just how fundamental the changes were as the automobile was adopted by our nation, consider that when "in 1909, at the end of Theodore Roosevelt's administration, his successor, William H. Taft went to the Capitol to be inaugurated, the horse-drawn vehicle he rode in did not differ essentially, except that it had four wheels instead of two, from the carriage in which Caesars rode out to the Roman baths during the first century of the Christian era. . . .Four years after Taft's inauguration, his successor in the Presidency, Woodrow Wilson, rode to the Capitol in a complicated product of physics and chemistry. . . .The distance between the Wilson automobile and the Taft carriage was, in time, four years: in material change, it was fully twenty centuries. The distance between the Taft carriage and the Roman chariot had been, in time twenty centuries; in material change, practically nothing."[38] Just as the conveyance had not changed in over twenty centuries, neither had the roadways.

The rising popularity of motor vehicles made this inadequacy all the more glaring as their numbers grew from just eight thousand in 1900 to over nine million by 1920. Once automobiles and trucks became commonplace, the nation found itself with a

woefully insufficient road system, incapable of meeting the demands of a nation turning to motorized vehicles as its primary source of transportation. Their assimilation into our culture precipitated many changes and impacts to our society, economy, political structures and environment that would inextricably alter all of them in the process. It could be argued easily that motor vehicles define our culture. The country would play a continual game of catch-up, to an ever-growing need for better local and regional roads and their integration into a web of long distance national roads, for decades to come.

As automobiles and trucks ventured down the road beyond the cities' edges, a completely new set of conditions emerged. Automobiles provided individuals a personal, private means of transport, trucks allowed farmers to reach broader markets and commercial trucking enterprises transporting goods over long distances, all traveled over roads owned by governments, but were virtually free of any responsibility toward the infrastructure on which they traveled. This new paradigm required an extensive reappraisal of the country's existing roads and infrastructure, their condition, how they were administered and the sources of funds for their maintenance, improvement and expansion.

The various transportation systems that made their appearances during the nineteenth century had always provided both the vehicle and the infrastructure necessary for their successful operation. Motor vehicles, however, were fundamentally different. Prior systems of transportation were essentially self-contained, *i.e.*, they provided both means and conveyance. Motor vehicles changed the equation by separating the vehicle from the infrastructure in the sense that the responsibility for funding and building the infrastructure necessary for its operation was provided by others.

How the "by others" scenario was played out has everything to do with where, when and why government funds were first allocated for roads and the course our road network initially took. If government is responsible for providing the greatest benefit for the largest number of constituents, then roads connecting urban centers with outlying towns and villages possessing the largest potential to contribute to the economy of a region will be funded first. The call for good roads first championed by bicyclists and farmers in the 1890s was quickly co-opted by business and investment interests when they recognized the economic potential a system of good roads could contribute to the vitality of a region. Instead of looking to improve the plight of farmers and rural communities, public infrastructure funds were most often spent where they were the most beneficial to these interests, along the routes connecting and spreading outward from urbanizing regions.

At the dawn of the twentieth century, the country found itself in a period of tumultuous change, "a time of endings and beginnings, of the commotion that goes with clash of old against new, the momentum of the innovation against the inertia of the established."[39] The traditions and values of the past were being challenged on a multitude of levels. The cumulative effects of the discoveries, innovations and advancements made during our transformation from an agrarian to an industrially oriented society, were generating both solutions and new problems for the nation. Motor vehicles played a significant role in these changes; both literally and figuratively they were the driving force behind the transformation of our culture and environment. As the nation proceeded into the twentieth century, government bureaus began the task of crafting comprehensive legislation and programs for road administration, but finding consensus among the

various needs and desires of states and their constituents, from the business community to the individual, was difficult. Were roads to be an engine of economic opportunity, or were they to follow the path of economic development forged by private enterprise? The pendulum swung both ways, but more often tilted toward following the money of private enterprise, leaving the roads of most rural regions unimproved. In the same way that the small blood vessels at the tips of the fingers and toes are the last to receive the benefits of circulation, so rural roads far removed from urban areas were the last to see improvements to their roads.

Road Design: Characteristics And Evolution

The evolution of roads from paths first forged by migrating herds and tribes to the modern thoroughfares we now negotiate daily, has spanned more than two thousand years. From the beginning, terrain and purpose have been the dominant variables affecting why roads are where they are. Whether for military purposes, trade or settlement, the earliest roads were rarely more than trodden paths. The Roman Empire was the first civilization to alter these fundamental parameters of road development. The Romans constructed a network of engineered roads starting in Rome that stretched to the far reaches of their empire. Many of these roads still exist today; their longevity can undoubtedly be attributed to the methods of construction they employed.

Roman roads were built to standards of monumental proportions. In comparison to what had been and would be built for nearly two millennia, they had no equal until the French road network built during the Napoleonic period, and still later, the United States interstate highway system constructed in the twentieth century. The Romans were

consummate road builders, having both the assets and ability to construct the roads necessary for their empire's function and expansion for centuries. Their army, assisted by skilled laborers and slaves, doubled as a road-building labor force. It possessed within its ranks the engineering knowledge and management capabilities required to execute the building of civilization's first network of engineered highways. Their paths spread throughout Europe, Asia, Northern Africa and Great Britain, tying "together the important cities of the empire in a great network for easier communication and commerce, and it facilitated the movement and supply of military units,"[40] totaling over 50,000 miles.

Roman roads are still with us today because their builders thoroughly understood the most important principles of road construction: good drainage and a solid foundation built upon undisturbed or compacted sub-soils. Their prowess is evident by some of their roads having outlived their builders by over fifteen hundred years.

Construction Methods And Materials Evolution

The Romans began construction by excavating below grade three to four feet, tamping the soil firm, then building back up with large stones to a thickness of one and a half feet. A layer of smaller stones bound together with mortar approximately one foot in thickness followed this foundation bed. Another lift was placed atop this layer, but with much smaller stones and a raised crown to aid drainage. The road surface then was finished with six-inch thick paving stones, crowned and grouted with a cementious mix that incorporated curbs along their edges (Fig. 1). The width of their roads varied between thirteen and seventeen feet, depending upon the locations through which they

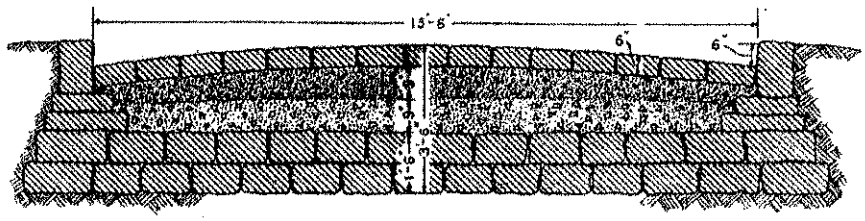
passed. In heavily trafficked areas, they sometimes incorporated narrower shoulder roads along their sides as well.

Beside the sheer mass of their foundations, the alignments of their roads were unlike any built before. Emphasizing efficiency, their roads were laid out as straight as possible regardless of the obstacles in their paths. To achieve this objective, hills were flattened, marshes drained and filled, and valleys elevated. If the gradient of their cuts equaled their fills, there was little wasted labor or material expense. Absent the need to overcome truly formidable obstacles, straight roads were easier and quicker to construct than sinuous roads and likewise to travel. An interesting aside to Roman road construction is that the Romans had not developed a pivoting mechanism that would allow their wagons, carts, or chariots to turn, making any variation in the road path difficult to negotiate.[41] Essentially, they would skid around turns. How this might have influenced the decisions behind their road alignments the author will leave for others to investigate.

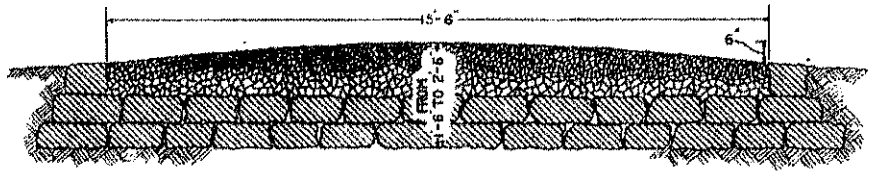
When the Roman Empire crumpled in 475AD from attacks by "barbarians," their roads were left to the elements and many slowly decayed. Though many also remained thoroughfares for centuries, others fell victim to the feudal Middle Ages. "A great deal of mileage deteriorated from frost heavage, subsidence and the depredations of local people who used them for quarries."[42] For centuries, none of the fledging fiefdoms became wealthy or powerful enough to carry on the building of public roads. Nearly fourteen hundred years would pass before any nation would achieve the political stability and wealth necessary to once again take on the task of building a network of public roads.

France was the first nation to resume construction of a national road system. Initially, they followed the Roman method, but for a few less inches of foundation material and smaller stones and gravel for the finished surface. During the last quarter of the 18th century, Pierre Tresaquet developed the first major advancement in highway construction. His design called for a width of eighteen feet, but was only ten inches in depth. To assist drainage, not only was the surface cambered, but the excavation as well had a similar crown. The foundation stones were then set on their edges and covered by a layer of crushed stones and graded. The advantages to this method were that fewer earthworks were required, and thus appreciably less labor and funds were necessary for their construction. Roadbed drainage was greatly improved by placing the foundation stones on edge, providing many more conduits for water to escape than if they were laid on the flat, where water would tend to meander horizontally before finding an escape between foundation stones (Fig. 1).

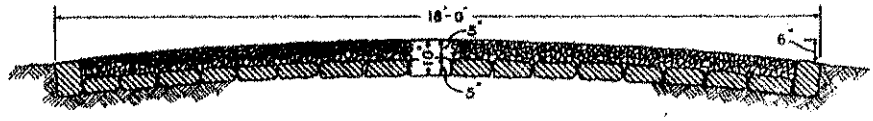
Improvements in road design were occurring in Great Britain as well. During the first decades of the nineteenth century, Thomas Telford and John McAdam were coincidentally working on solutions for their country's terrible road conditions. Telford's road design was based on a foundation of large stones laid on compacted flat sub-soil, followed by layers of smaller stones sorted by size, then finished with fine stones and rock dust to a crowned thickness of fourteen inches compacted to a tight hard surface. McAdam's design was radically different (Fig. 1). He eliminated the large foundation stones that had been the mainstay of road construction since the Romans and decreased the road depth to only ten inches. His design called for a crowned, compacted sub-grade followed by layers of exceedingly smaller stones, each compacted, so as to interlock the



Ancient Roman 2-Lane Military Road

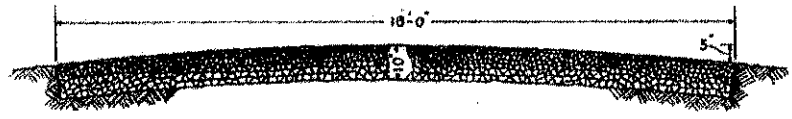


French Road (Roman Method) Previous to 1775.

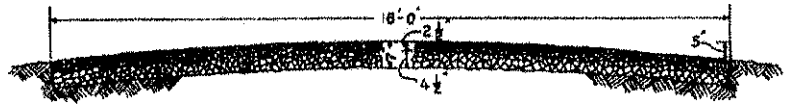


Trésaguet Road, France, 1775 to 1830.

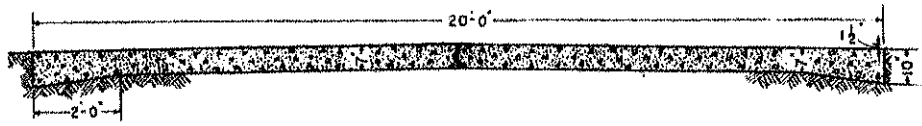
Telford Road, England, 1820.



Original Macadam Road, England, 1816.



Macadam Road, United States, 1900.



Heavy-Duty 2-Lane Concrete Pavement, United States, 1943.

Figure 1: Cross section of roads from ancient to modern times.
[Source; *The American Highway*, William Kaszynski, 2000]

aggregates into a hard durable gravel surface. His design permitted better sub-grade drainage, and with continued use the roadbed became firmer, a consequence attributable to the smaller aggregates used in construction. The smaller aggregates allowed an infinitely greater number of passageways for water to move through, while settling into an ever-tighter substratum from the passage of traffic (Fig. 1). McAdam's road design won favor over Telford's because it was effective, and cheaper and easier to build. It became the adopted method for new and improved road construction in the United States by the turn of the 20th century. McAdam's contribution to road design is honored by the widely used generic term "macadam" for describing a road type.

Macadamized roads, though well suited for horse-drawn vehicles and the relatively slow speeds at which early automobiles traveled, were never designed to withstand the wear and tear of motor vehicles and the perpetual, seasonal erosion as well. The combination of freeze and thaw cycles, and the increased speed capability, weight and number of vehicles traveling on macadam roads turned their surfaces into landscapes of potholes, ridges and ruts. "Macadam roads had to be resurfaced frequently, as the roadway quickly disintegrated under the weight of traffic."[43] Though they were improved somewhat with the addition of a binder, such as tar which consolidated the paving into more durable surfaces, the burdens placed on them by our autocentric world were more than they could handle. A more long-lasting solution to the country's need for hard surfaced roads to satisfy the wheels of transport and maintain the daily functions of the nation was required.

Coinciding with the period of soaring automobile production that followed introduction of the assembly line, were large-scale developments in petroleum refining

technology. Not only did refineries produce the fuels, oils and lubricants used by the automotive industry, but a by-product of their refining, asphalt when combined with sand and gravel was found suitable for road building. Experimental testing found both asphalt and concrete, though different, had the properties necessary to provide the all-weather, hard paved surfaces the nation's roads needed. Asphalt is known as a flexible pavement, whereas concrete, because of its inherent stiffness, is defined as a rigid pavement. The fundamental difference between flexible and rigid pavements is the way in which they distribute loads to their sub-grade; but it would be decades before road builders understood the details of their application as paving systems. During the interim most roads continued to be improved with gravel, combined with bituminous binder's spread across the road to consolidate their surface.

Flexible pavements, commonly called asphalt roads, are constructed of two or three layers of material, depending on their sub-grade capabilities, which deflect and flex under loading. Loads travel down through this flexing structure in a cone-like pattern, from a point on the surface to the compacted sub-grade, spreading the load over a larger area and reducing the actual load borne by each layer as it is transferred to the sub-grade.[44]

Rigid pavements are composed of concrete. Concrete, being substantially stiffer than asphalt, has an entirely different set of properties and capabilities. Rigid pavement can act like a bridge over compacted sub-grades; because of the intrinsic load-bearing ability of concrete, loads are distributed over a much wider area of the sub-grade (Fig. 1). Given the high elastic modulus of concrete and depending upon the sub-grade conditions, additional structural sub-base layers are sometimes not required for concrete pavements.

Concrete consists of three basic ingredients: cement, sand and gravel mixed with water. By altering the quantity and ratio of these ingredients, different qualities are produced that allow maximizing the properties of each batch for a specific application. Additionally, concrete can be reinforced with steel, adding to its structural capabilities, while reducing the need for joints to control cracking.[45] What began over twenty-three hundred years ago with the Appian Way is still evolving, material sciences continue to refine the properties of these pavements to better withstand the pounding our roads receive from the increasing vehicle miles they experience.

Road Standards And Regulations

Good roads might have meant more goods taken to town for sale and returned home from the store to improve rural life, but what were the material specifications and standards of a good road? Before joint federal and state participation in road building was established by the Federal Aid Road Act of 1916, road building and improvements had been the jurisdiction of local governments. How they were built had more to do with the availability of local labor, funds and materials, than an understanding of engineering concepts or the properties of various materials.

The phenomenal growth in automobile and truck ownership and the self-interest of the motor industry generated sufficient public support and political power by World War I to exert tremendous pressure for a larger federal role in improving the nation's roads to accommodate what was rapidly becoming a motor driven culture. New disciplines in civil and mechanical engineering were needed to grapple with the numerous dimensions presented by this re-ordering of our transportation network. But,

"between 1920 and 1930 it was not even recognized as a specialty within the American Society of Civil Engineers. Road designers in the 1920s had to work within an emerging field of knowledge that developed through actual application,"[46] essentially on-the-job training. This lack of knowledge about road construction methods and transportation planning for motor vehicles called for the development of new engineering guidelines and standards to build our nation's transportation network.

World War I began nine months after President Woodrow Wilson signed the Federal Aid Road Act. The war drastically curtailed road construction, as road building materials were diverted to the war and many workers were either in the military or employed in the war economy. It was abundantly clear when the war ended in November 1918, how important road standards were to the nation's prosperity. During the war, "heavy use by vehicles serving the war effort mainly proved that America's poorly constructed roads could not take the pounding. Overburdened railroads yielded freight to the growing trucking industry, which added to the loadings undermining the thin or nonexistent road surfaces of the day."[47] Additionally, trucks manufactured in the midwest, destined for the war, heavily laden with equipment and munitions, were driven to ports of departure, while at the same time truck and automobile registrations increased throughout the decade. Without comprehensive standards and specifications for the best methods and materials for constructing roads, whatever amount of money might be dispersed for their maintenance or construction would be wasted. All told, motor vehicle traffic was consuming the roads of the country.

In 1918 the Bureau of Public Roads (BPR) began research toward establishing such standards, at its Experimental Farm in Arlington, Virginia, by measuring the impact

of various wheel loads upon different road surfaces. By 1920, the newly-formed Advisory Board on Highway Research was conducting research and developing material standards for road construction methods, and guidelines for the safe and efficient passage of traffic along the nation's roads and highways. The Advisory Board was renamed the Highway Research Board in 1924, and in 1974 became the Transportation Research Board.[48] Yet, even with the early formation of research programs, it wasn't until the 1930s that transportation engineering was recognized as a professional area of study, and still twelve years later before the national Institute of Transportation Engineers published the first Traffic Engineering Handbook.

Road building trade associations like the American Road & Transportation Builders Association, originally an outgrowth of the League of American Wheelmen, formed in 1902, also contributed to road standards and their construction specifications. Their approach was twofold. Sponsoring "road shows," they demonstrated construction equipment, materials, machinery and best practice methods for road construction to contractors, businessmen and state and federal representatives. The second aspect of their approach, where they were most successful, was promoting their services to government road officials.[49] They lobbied for enhancing the nation's road system by promoting the benefits roads would bring to the nation, while being mindful and protective of their industry and livelihood. Because road building involved large sums of government money, it spawned major political jockeying for where the money for roads would be spent. In this arena, road industry lobbyists have always focused on the benefits of their endeavors cloaked in the language of safety, efficiency and a better quality of life, but

have shown little concern for the ecological and cultural effects their highways have had, and will have.

Roads And Their Edges

Once automobiles had the capability of high speed, " the sharp curves of the old alignments, easy for horses and wagon to negotiate, were often lethal to automobile operators and their passengers. The high-slung cars skidded on curves and turned over, or plunged head on into each other, or slammed full tilt into the fine old roadside trees."[50] Roads that had serviced our needs for centuries were suddenly rendered obsolete. But more than just new roads and road improvements would occur. It was beside the roads, along their edges, that the transformations that would permanently alter the fabric of our landscapes began.

There are fundamental attributes common to all improved roads that set them apart from previous roads, namely, they were raised above the abutting land, had ditches along their edges and were graded to direct water to their edges. The sequence of improvements started with the ditches along the roadsides. "By digging two parallel trenches[51] and depositing the leftover earth between the trenches," a raised roadbed, or "highway" was created. Over their life spans, their surfaces would have been improved with some form of paving, their alignments might be straightened and their sight lines and grades improved by cutting down the higher elevations and raising the lower ones along their paths. Though roads had been initially maintained or improved by the labors of their abutters and later by department of transportation road crews, the degree to which any road experienced improvements is still, as a rule, tied to its location and alignment within its hierarchy, and the availability of funds for its improvement. The existence and

location of many of our oldest rural historic districts is directly related to where the earliest of these roads developed. In the following case study (Chapter IV), the means and methods of improvement their roads experienced will be explored in light of these parameters.

Road Types

Road building in the United States has concerned four distinct purposes: defense, commerce, development and travel, serving "different but interrelated components of American life, each of which contributed to the economic welfare of the nation."[52] Foremost during the late 20th century were defense roads such as the Interstate Highway System. Part of the rationale for its construction was to provide for the movement of troops and equipment quickly and unfettered, and the evacuation of cities, if and when the need arose. Roads for commerce and trade were built to facilitate the flow of produce and products throughout the country. New housing developments built around the periphery of urban centers were in constant need of new roads to keep up with the country's spreading populace. Lastly, roads for travel, recreation and tourism were built to accommodate leisure time driving.

Conceptually, the purposes and reasons for these roads were and are clearly beneficial, whether fulfilling a need, providing a service, or expanding economic opportunities. However, they also caused changes not easily measured in dollars. It was along the sides and edges of these various road types that the most dramatic changes took place. Natural landscapes were altered and molded into new contours and elevations to accommodate the purposes for the roads' construction. The functional aspect of their

construction is easily understood, but how their paths came to follow one alignment instead of another is clouded in numerous subplots of political maneuvering, influence peddling, and speculative investment interest. The appropriateness of their rights of way was most often determined not by the best location according to sound engineering principles, but by the politics of profit.

Road builders became adept at the fundamentals of drainage systems, sub-grade supporting foundation systems and surface treatments, while politicians became proficient in bringing transportation dollars home to their constituents. With exclusive focus on such agendas, what was lost along the roadsides has transformed not only the physical environment, but the visual and cultural landscape as well.

The 1920s were not just a time of raccoon coats, ragtime jazz and prohibition alcohol, but a time when people in many regions of the country were able to venture beyond the mud-swallowing roads of their past onto new improved, all weather, year-round roads for the first time. Until the 20th century, road builders had relied on the labor of men and beasts of burden to move the earth and rock necessary for their construction projects. "Over the years men wielding shovels and pickaxes and driving horse-drawn wagons yielded to power shovels and dump trucks. Engineers began using bulldozers along with large power shovels to make cuts and grades more efficiently[53]," to build their roads. The 1920s witnessed an unprecedented surge in road improvements and building within the United States; all the necessary conditions had finally fallen into place. By the end of the decade, the BPR "had built or resurfaced over 90,000 miles of federal-aid highways."[54] For the first time in centuries, a nation had not only the political support,

financial capability and economic incentives, but also the will to develop a national road network.

Effects Of Roads Upon The Ecological And Cultural Fabric Of The Landscape

Under the guidance of civil engineers from the BPR and state highway departments, the character of the nation's roads was radically altered to standards of construction unimaginable only a few years before. Their designs for widening roadways, straightening curves, raising valleys, lowering hills and easing gradients made the nation's roads safer, more efficient and contributed to the economic prosperity and well being of the driving public. However, a myopic perspective that tended to give short shrift to other important aspects of their projects accompanied the technocratic focus of their engineers. Their approach ultimately failed to recognize or consider the impact their projects would have on the natural, cultural, and physical environments where their road improvements took place. Accordingly, the implementation of their designs resulted in consequences often disruptive to both the natural and human environments surrounding the areas where they were introduced. They changed the physical and visual fabric of the area, and altered the long-established balance communities had achieved with their natural environments.

The same consumer benefits urbanites had been enjoying for years thanks to the fruits of technology and industrialization crept toward the countryside along the roads as they were improved. "The automobile increased rural access to consumer culture and had a dramatic impact on the economic geography of rural society."[55] What was once only available after an all-day journey, now became a short errand or a pleasurable shopping

trip. Local merchants, especially general stores that catered to most everyday needs, were unfortunately, adversely affected by the larger, cheaper and more stylish selection of goods now readily accessible in larger towns and cities. Though the distances had not changed, the time to travel them had. In the same way that rural farmers were able to deliver their products to market more expeditiously, merchants from the larger consumer economy now were able to market their wares to the once distant rural areas.

This perpetual motion of change saw new enterprises spring up along the roadsides. Service stations appeared at the road edges, dispensing fuel and basic services for the motoring public. In cities, towns and villages automobile repair garages replaced livery stables, and auto dealerships displaced the traditional craft of the carriage maker. As paved roads and motorized vehicles led the way for expansion of the market place, the push and pull of these economies flowed along the improved and expanded highways of what was becoming a centrally controlled network of state and national roads for individual and commercial transport.

Rural society, which had long clung to the independence and autonomy that control over their local roads gave to their lives, reluctantly surrendered that control to government administered road departments when the benefits of governmental administration outweighed their ability and motivation to oversee their roads at the local level. What was once seen as threatening to their way of life was now perceived as a benefit that provided them with the mobility to engage in the larger world and its opportunities, just down the road a mile or two.

Though there is no doubt that widening the rights of ways made for the safer passage of vehicular traffic, in so doing the landscape was irreversibly altered. The

process removed stands of roadside trees and relocated decades-old drainage ditches, that had delineated the edges of fields and property lines along the old roadbeds. These natural transitory strips that had evolved over years of settlement, separating the road from cultivated fields, that were home and shelter to wildlife, that acted as buffers from winter winds and a respite from the summer sun, and that had given the landscape a vernacular texture, vanished into the widened rights of way. Their widening moved drainage ditches onto abutting lands, changed run-off patterns, and contributed to erosion and the silting of streams. As curves were straightened or made gentler, their paths consumed more land, altering the roadside environment in the process as earth was moved to blend the transitions between grade changes into gentle slopes. Simultaneously, the natural topography was reordered; each new addition or improvement to the roadways was accompanied by an alteration to the existing natural environment that in turn had numerous lasting effects upon the social and cultural environments of the landscape.

There is no denying that the improvement and building of new roads was a dual-edged sword that sliced through the visual and cultural landscape of our forebears' road alignments, while ushering into the countryside the cutting edge of a rising consumer culture and the mobility long enjoyed by urbanites, with all the attendant benefits improving the quality of life. To this day, the jury is still out; there are those who pine for what was lost, just as there are those who will applaud what has been gained. The most comprehensive interpretation still lies somewhere in the middle.

CHAPTER III
PAVING OF ROADS IN RURAL HISTORIC DISTRICTS

Not long ago, the designation "historic district" did not exist. In 1931, the city of Charleston, South Carolina established the United States's first historic district with supporting preservation ordinances. Preservationists' main focus had long been the protection of individual buildings, prominent estates and urban historic districts. In 1966, The National Historic Preservation Act (NHPA) expanded those perspectives when Congress declared, "the historical and cultural foundations of the Nation should be preserved as a living part of our community life and development in order to give a sense of orientation to the American people."[56] Since then, the number of historic districts has grown to over 2,300. Yet, people have never decided they were going to build an historic district. Legitimate historic districts are not manufactured; they owe their existence and recognition to the occurrence of events and the passage of time. Before they were recognized as possessing significant historical qualities, they were just old towns or the oldest parts of towns.

The roads of historic districts have evolved in the same manner as that of all roads, by following the growth of their population and economies. To what degree their development continued depended upon whether they remained on the geographic path of population growth and economic development. If so, their roads continued to see improvement, and if not, may have remained in the mud well into the 20th century.

Considering growth and economic development, roads in urban historic districts have experienced many more mutations to their structures and character because of their locations, the nature of their spaces and the concentration of assets around them, in comparison to those found in rural historic districts. Though the roads of both urban and rural districts served many of the same purposes, they developed under entirely different circumstances and evolved at different rates.

Urban historic districts are found in and around centers of commerce and government where roads have traditionally spread outward following development and growth. Rural historic districts, though at the same time central to a region, more often owe their existence to the progression of roads that lead toward them from outlying areas. Whereas urban areas needed to exercise control over their expansion, plan their development and anticipate their public works needs, the roads of rural regions, never having attained the level of growth and development of their urban counterparts. They have evolved more like the indigenous roads of the past.

Analogous to the background of a photograph, historic districts quietly display a wealth of information about their past lives; their roads and supporting infrastructures offer a glimpse into their histories for the studied observer. How their roads developed and evolved as various methods of construction and paving materials were introduced into their environs can illuminate many dimensions of that past. Because of their longevity, historic districts are a primary source for investigating how the evolution of paved roads has affected not only the economic and physical fabric of the district, but the social and cultural worlds of its inhabitants and their surroundings as well – the human environment.

Conditions Before Paving

The first roads in what are now rural historic districts, were nothing more than primitive paths and trails, traveled by Native Americans, frontiersmen or settlers. The ways of these areas evolved in conjunction with the paths leading to them, one supporting the other as they developed communally. Over decades, under the weight of increased local traffic, they slowly matured into roads, defining a village's layout and delineating the connections between outlying farms and other villages. As time passed, they experienced changes and modifications as the socioeconomic dimensions of their community and use evolved. What was once an ill-defined patchwork of ways that shifted according to the dictates of the seasons and topography, developed into an identifiable system of roads, "tying together at one central place all the spaces which constitute the territory of a community,"[57] as settlements and villages grew into local economies.

Scale, Direction and Intent

The scale of roads within rural historic districts are substantially different than those of modern communities. The feeling and sense of intimacy they exude that makes them so comfortable and inviting to visitors and residents alike, is perceived in part because of the enclosing nature of their scale. Their narrow streets lined by buildings, set close together near the street's edge and the tree canopies that envelope one's spatial perceptions, all contribute to their sociability. However, they were never spatially conceived or built to massage the senses of the citizens of the future. They evolved in

response to the socioeconomic needs and conditions brought on by their communities' growth during earlier times.

During the eighteenth and nineteenth centuries, the world of rural inhabitants was much smaller and removed, an insular world where their spiritual, social and material needs were all found within their communities. The ambit of their travels was measured by how far they could go in a day by horseback or wagon. It was a time when the purpose of roads centered on their communal needs, and then as they emerged from rural isolation, the roads gradually grew into fixtures on the landscape, serving, shaping and defining the economic and cultural geography of rural society.

Rural historic districts owe their existence in no small way to the roads that lead to them. For centuries their roads had turned inward: defining, strengthening and maintaining the social order. As the twentieth century approached, new possibilities for improving the quality of life were becoming available to rural residents that would transform the age-old order of their communities. Since the time of settlement, their roads had played only a small part in the history of their communities' material progress, but all that would change once the useful products of industrialization laying temptingly close, just beyond the nearly impassable muddy tracks at their doorsteps, could be reached.

Reasons and Benefits of Paving Rural Roads

Long before the first automobile ventured beyond the urban edge to the countryside, there were two opposing schools of thought on what the desired benefits of good roads should be. Both factions extolled the need and supported the ideals for good

roads, but they differed in how each defined and approached the implementation of those goals.

On one side were the various reform movements that coalesced into the "Good Roads Movement" at the turn of the nineteenth century, which advocated progressive reforms to enhance the quality of rural life. On the other were businessmen, developers and road building associations all lobbying for progress, in wake of the automobile's rise in popularity beyond a mere convenience, through economic development of the most lucrative motor transport corridors. On the surface the debate between progressive reform and progress was over improving the conditions of rural-farm-to-market roads, or improving and building long distance roads between prosperous cities and potentially profitable regions of the country. However, lingering just below the surface were many other issues that can best be described by the mutual, yet at times conflicting, goals of increased accessibility and modernization.

Good Roads advocates saw road improvements as a fundamental avenue for improving the quality of life of rural residents by making them more economically efficient and thus more prosperous as a result of affording them the means and access to the larger world of consumer goods, cultural events and educational opportunities their urban neighbors enjoyed. Their definition of progress included both economic and cultural dimensions: better roads would improve rural society and the agrarian economy. Their opponents in this contest of influence tweaked this definition of prosperity to that which would benefit the state and country's economy as a greater good. By co-opting the Good Roads agenda of improving the quality of life, but limiting the terms to business

and economic interests, with cultural dimensions remaining ancillary, they were more successful in finding support.

In a country originally founded on principles of laissez faire, it is not surprising that when the government finally did commit to funding for roads, the money was spent on economic development rather than progressive reforms. The first roads to see improvements and paving were those long distance roads that carried the greatest traffic volume to and from prosperous industrial cities. As traffic loads increased, these same alignments were widened further, their curves became straight-aways and the hills they once ascended were sliced through, turning the roadways into throughways. Government road policy continued to support the country's economic development during the 1920s, instead of stimulating economic progress for rural areas through road improvements. Years would pass before rural regions would see such investments in their infrastructures.

For rural historic districts extant today, the success of the "greater good" advocates was a blessing in disguise. Their geographic isolation, combined with the lack of governmental interest in, and funds for, improving their terrible roads allowed them to remain relatively inaccessible, and unchanged during a period when many other regions of the country experienced new levels of growth and improvement to their transportation infrastructures. In other words, the fact that these districts were distant from the influence of progress allowed them to retain their integrity.

Road improvements extended into rural regions of the country for the first time during the 1930s and 1940s. Demands from the motoring public, travelers, residents and business leaders alike, reflecting their view of motor vehicles as an indispensable part of rural and urban life, could no longer be ignored. "The rural road as it was once known –

the quiet, treelined thoroughfare with branches meeting overhead, and interesting curves and aspects,"[58] was about to disappear from the landscape. Their paths were realigned, widened and straightened to improve passage for motorists. These needed improvements were directly related to the demands and pressures brought about by the dramatic increase in motor vehicle ownership and subsequent traffic increases, not the calls for progressive reforms or economic progress heard over the previous thirty years.

Implementation and Responsibility

From the time our nation was settled, local governments had been entrusted with the responsibility for administering, managing and constructing local roads. Each county or district appointed a road overseer or surveyor to manage the construction and maintenance of a district's roads. The labor to accomplish these tasks was provided by road tax statutes under which a farmer, "could pay his road tax with his own labor or that of his sons and hired men, as well as through the use of his draught teams, wagons and tools, which made it less of a burden than a cash levy."[59] For centuries, this system had served the needs of rural society, but would prove to be inadequate for the changes about to take place as the nation entered the twentieth century.

The arrival of horseless carriages revolutionized our means of travel. What had begun as a cottage industry in the 1890s quickly grew, within two short decades, into a major industry even as the roads on which motor vehicles traveled remained more suitable for horse-drawn carriages. Little had changed in how the country's roads were administered. As automobile registrations grew exponentially, new sets of rules governing road administration became essential. While professional management and

engineering know-how were certainly important, the biggest obstacle to surmount was how to finance improvements and construction.

Virginia Roads, Responsibility, Administration and Maintenance

In 1906, the Commonwealth of Virginia established its first Highway Commission, but appropriated only enough funds to cover the commission's operating expenses. Counties remained responsible for all roadwork; the Commission's dictate was to assist with engineering and technical advice on the best methods for improvements. The Commission also was charged with encouraging county officials as they improved their roads to look toward connecting them with those of surrounding counties into regional road networks.

State funding for road construction was approved for the first time in 1909, but it required counties to match the state's contribution up front. However, at the same time the state allowed counties to levy real estate and personal property taxes to raise those funds and to issue bonds for the same purpose. These methods, while a step in the right direction, were never sufficient to cover the costs for the needed road improvements. The following year, the state raised additional road funds through charges for motor vehicle licensing and registration fees. By 1916 the number of registered vehicles in the state had grown from just 2,705 in 1910 to over 37,000.[60] Still, the revenue from these measures was not enough to cover the cost of improvements. Additional means of financing were needed to repair the damage roads absorbed from the daily increase in vehicle miles they experienced and to still the public's clamor for better roads.

Throughout our history, federal authorization and funding for roads beyond the local or state level has been problematic, from Thomas Jefferson's approval for the National Road, to Dwight Eisenhower's plan for the Interstate Highway System. The states, while jurisdictionally empowered, lacked the financial resources; on the other hand, the federal government had the financial ability, but lacked the jurisdictional authority to contract for road improvements. The question has always been whether the federal government has jurisdiction to construct roads within a state, which translates into an argument over the sovereignty of states rights versus federal control.[61]

The continued search for funding led to the Federal Road Aid Act of 1916, authored by the newly formed American Association of State Highway Officials. Its proposal, once adopted, became the first legislation to authorize federal participation in road construction. Though not a perfect solution, it initiated the relationship between the states and federal government that was sorely needed to begin addressing the universal problem of the nation's poor roads. But even with new federal funds entering the coffers of state highway programs, the states were still unable to contend with the ever-growing number of motor vehicles on their roads. A new Federal Highway Act enacted in 1921 alleviated many of the shortcomings of the 1916 Act, but revenue and federal aid still remained less than necessary to keep pace with the country's road needs.

In 1919, to increase their revenues further, many states began levying a tax on the sale of gasoline. Within ten years, every state in the union had instituted a gas tax. The tax proved so successful and perpetual, driven by the continual increase in production numbers for motor vehicles, that it became the main source of revenue for state road building and maintenance programs. So successful was the tax in fact, that the Federal

Government imposed its own tax on gasoline sales in 1932 to fund federal-aid road programs as well.[62]

In the Commonwealth of Virginia, an interim measure to deal with road improvement problems was established in 1918, when the state took over responsibility for the major roads and thoroughfares connecting the larger populated areas of the state. Calling it the State Highway System, this network of 4,002 miles was removed from the responsibility of local jurisdictions, lessening their road obligations to a degree and freeing up more of their resources for the other roads of their communities.

The formation of the State Highway System essentially divided the state's roads into two categories: primary roads, those maintained by the state through motor vehicle use revenues and the aid of federal funds, and secondary roads financed by county taxes. However, the majority of the state's population resided in rural areas, making their living from the land. The system of secondary roads that they were required to support through local taxes was comprised of more than 40,000 miles. Obviously, the counties saddled with so many more road miles and most of the traffic, but with only property taxes to fund their improvements, were never going to be able to get out of the mud. Adding to the dilemma, the number of motor vehicles per mile in the state increased from just over three to almost nine per mile between 1920 and 1930, with the majority of vehicles traveling the same county lanes where most people lived and worked. While the state system increased its mileage incrementally as funds permitted, the secondary rural county roads crumbled because of insufficient funds and the stresses from increased use, as more and more rural residents purchased motor vehicles.

In 1930, over six and a half million dollars was raised by license and registration taxes and another seven and a quarter million dollars by the gas tax for maintaining 7,191 miles of roads in the primary road system while the secondary roads continued their decline.[63] This imbalance was untenable. The demands for better rural roads could be ignored no longer as motor vehicles had become an essential and integral part of everyday life for rural residents.

In 1932, the General Assembly of the Commonwealth of Virginia approved what is known as the Byrd Road Act. Championed by the erstwhile state governor Harry F. Byrd, it permitted counties to turn over the responsibility for their local roads to the state highway commission. The legislation was long overdue given the economic importance of the sheer number of people whose lives were affected by their dreadful roads. The Byrd Road Act added over 35,000 miles of rural roads to the state road system. Over the next decade, the state's secondary, "hard surface roads had tripled to 6,000 miles, the mileage of soil and gravel roads had doubled to 17,800 miles and the unimproved roads had been reduced by half to 12,500 miles."[64]

For the first time, rural Virginians were able to drive their vehicles on year-round roads. The larger world that had remained out of their reach for so long was finally accessible now that they possessed the means and the way to conveniently travel beyond their communities' borders. New social and economic opportunities became available to rural residents, improving their quality of life and realigning the fabric of their world. Along these roads, where yet to be designated rural historic districts resided, the same improvements and enhancements were experienced. How they were able to retain their

historic integrity, while still receiving the benefits of society's advances is found in a web of circumstances and relationships specific to the events each district experienced.

Impacts: Direct and Secondary

All-weather roads would challenge the conventions of rural society. A way of life that had existed for generations, that defined the economic and social order of rural communities, was transformed with every mile of road paved. Nowhere were these changes more profound than within local villages, some of which survived relatively intact and are now rural historic districts. The roads of these communities help to explain the context in which they evolved. Their paving is one chapter of that context; the effects of their paving are many more.

Road paving produced numerous changes to the environs of rural communities, the most basic of which were their impacts on the natural and built or human environments developed over generations as people interacted with their surroundings, forming and modifying them to suit the needs of their communities and livelihoods. Road paving permanently altered those relationships.

Few, if any roads have escaped changes or alterations to their paths since being constructed. Historically, roads have either evolved from earlier routes or been engineered and built to design specifications for a specific corridor. The methods and techniques employed in the construction of engineered roads differ greatly from those of evolved roads. For this study we are concerned only with evolved roads, specifically in this case the roads of rural historic districts, that are also defined as "cultural roads" in *Saving Historic Roads, Design and Policy Guidelines,* written by Paul Daniel Marriott.

This text defines historic roads as "roads that, through design, experience, or association, have contributed to our culture in a meaningful way." It identifies "three types of historic roads: aesthetic routes, engineered routes and cultural routes."[65] The "cultural roads" of this study are examples of roads that developed without the benefit of engineered or designed plans, but rather through necessity and methods more appropriate for horse and wagon times.

Improvement Impacts: The Roads

Most rural roads saw little change or improvement until being adopted into the state Secondary Road System. Then the tools of industrialization restructured the roadscapes of rural Virginia. Road building equipment and machinery transformed a system of roads, once provincial in nature, scale and intent, into a surfaced rural road network. Their surface transformation began when the "older earth surfaces and broken-stone road systems were gradually replaced by surface treatments, initially bituminous binder over soil or broken-stone roads, and later concrete and asphalt paving systems."[66] However, the early bituminous treated roads surfaces did not hold up very well. Their porous surface allowed water to infiltrate the road, then quickly deteriorated under the weight of traffic loads, requiring frequent resurfacing.

Road alignments were often altered or relocated. The old roadways needed many alterations to accommodate motor vehicles. They were widened and straightened, and sometimes abandoned or realigned completely to satisfy the needs of safe passage for motor vehicles. The severity of the cuts and fills of many rural roads are so extreme they could not have formed part of their original alignments. It was along this path to

modernization that the character of many rural roads irretrievably lost their earlier features and appearances. Alongside many country roads the remnants of previous alignments are still evident. Fence rows, trees and phone lines running parallel to overgrown strips of ground, at times crisscrossing their new alignments, hint of previous paths. Beside many bridges can still be found the abutments of prior spans: at Catoctin Creek next to the Waterford mill, on Taylorstown Road (Route 668) next to the Taylorstown Mill, beside the North Fork of Catoctin Creek and Richards Creek on Milltown Road, (Route 681) just outside of Waterford, (See Fig. 2).

In the 1930s, road paving as a discipline was in its infancy, without guidelines or standards to direct the best methods for implementing improvements. As a result, road crews relied on prior experience and methods to improve roads. Road building as a professional discipline was just becoming recognized by the engineering community during this period. Not until 1942, did the National Institute of Transportation Engineers publish the first Traffic Engineering Handbook. In the meantime, road improvement methods evolved through trial and error.

Rural roads had few fixed gradients, elevations or infrastructures, to complicate their improvements; paving was simply applied to their soil surfaces. Problems arose when this same approach was used in settlements and villages where established grades, elevations, alignments and drainage infrastructures clearly defined the appropriate finished height for road surfaces. Yet, little was done to accommodate these benchmarks. The requisite knowledge needed to design and implement appropriate improvements was not available. As a result, the roads were paved-in-place. The drainage systems that had functioned for the unpaved roads became by default, without modification, the drainage

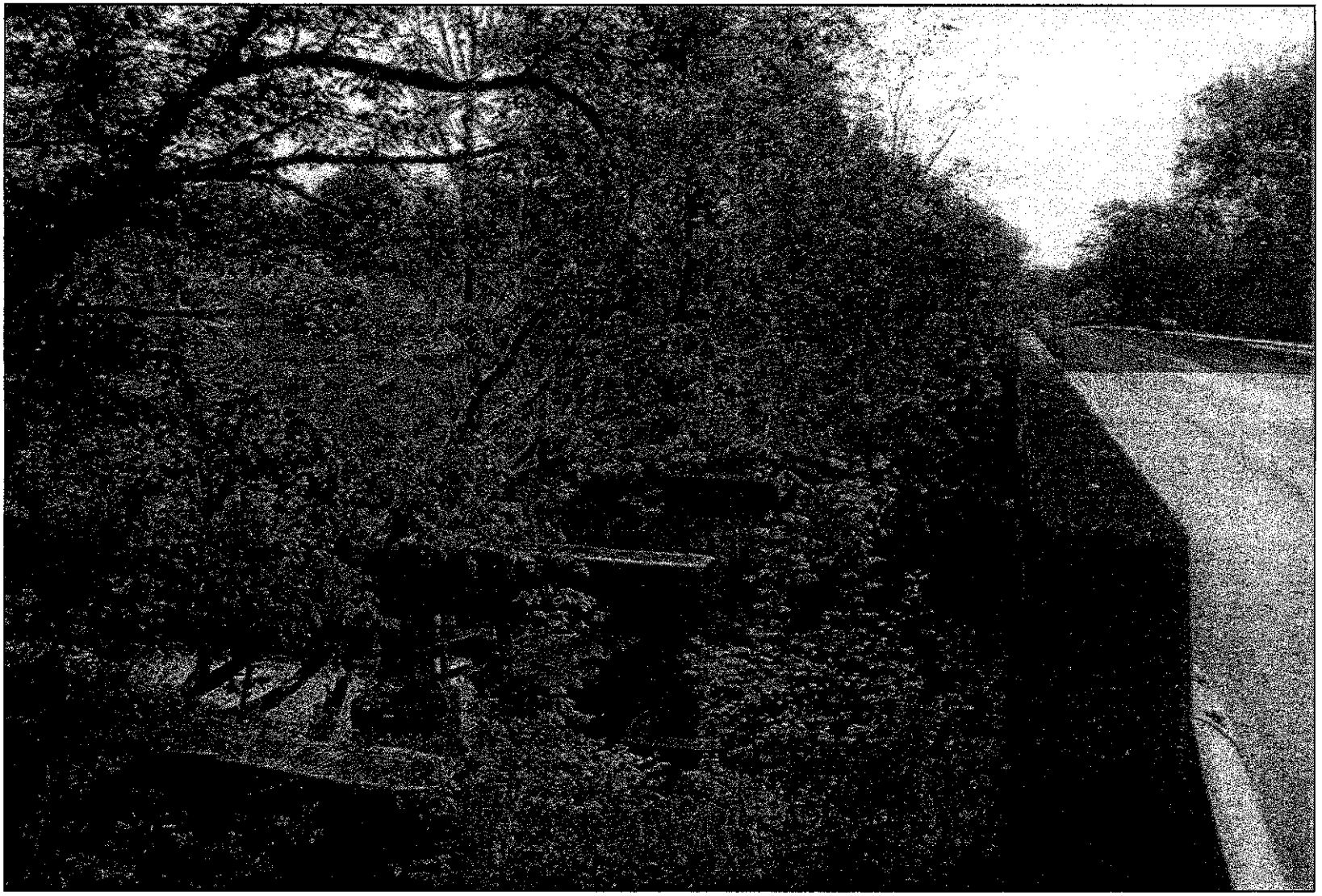


Figure 2: Remains of prior bridge, Richards Creek, Milltown Road, 2 miles north of Waterford, VA.[Source; Author, 2003]

systems for the newly paved roads as well. This rationale satisfied one goal: the most expedient, efficient and economical means to pave as many miles of rural roads as possible with the resources available. This approach was ultimately shortsighted. For the first layer or two of paving, the benefits realized may have overshadowed any damages incurred, giving this mistaken approach "surface" validity, but subsequent layers have revealed the fallacy of this approach, as seen in Waterford, VA. (Fig. 3).

Improvement Impacts: The Drainage Systems

Beyond their nominal traffic-carrying function, roadways are essentially water conveyance systems composed of pavement and some combination of shoulders, ditches, culverts, curbs, gutters and storm drains. Their proper drainage is a fundamental requisite. Without proper design, construction and maintenance, a road and its surrounding environment will be adversely impacted in untold ways (Fig. 4). The most important design consideration is the context in which a road is located, i. e., the existing conditions, roadside adjacencies and the community history and cultural resources through which the road passes. Within historic districts appreciation of this context is imperative, because the roads are a contributing element of a district's character and physical integrity.

Since passage of the Byrd Road Act seventy-two years ago, the shortcomings of this approach to improve the rural road network are evident. There has been a cycle of repetitive layers of paving applied to maintain the roads' surface integrity. This practice was initiated and continues to be employed, in absence of a designed road and drainage systems management plan. The result has been increased road heights and uncontrolled

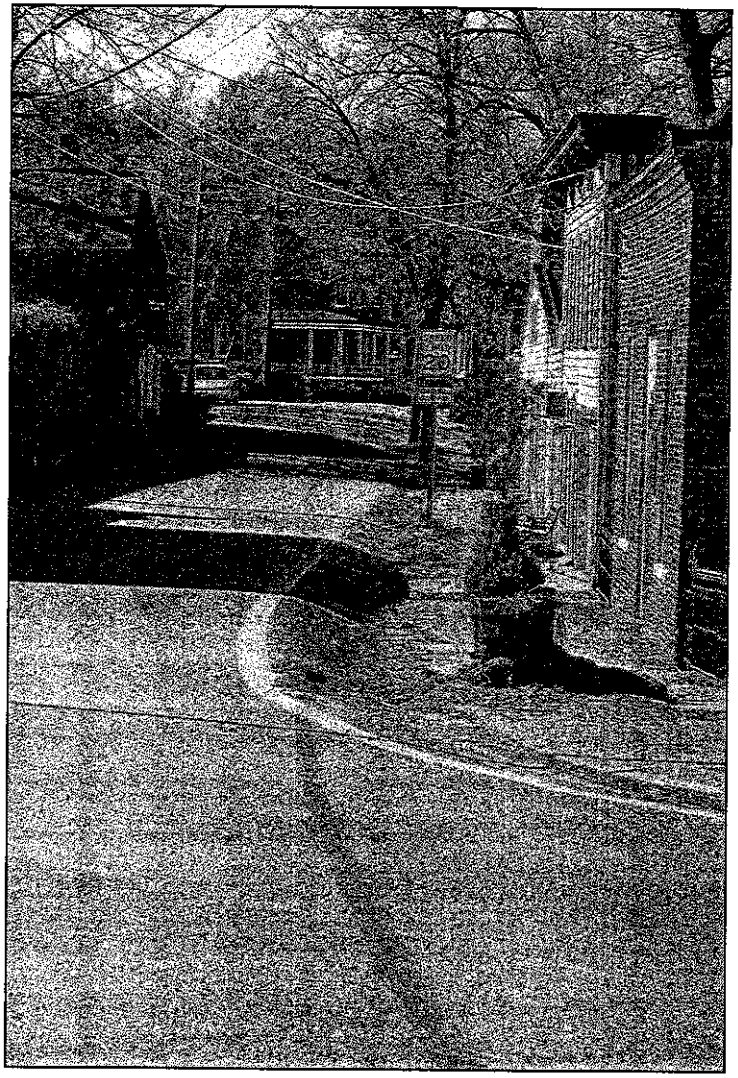


Figure 3: Visual and contextual impact from heightened road, Second Street, Waterford, VA. [Source; Author, 2003]

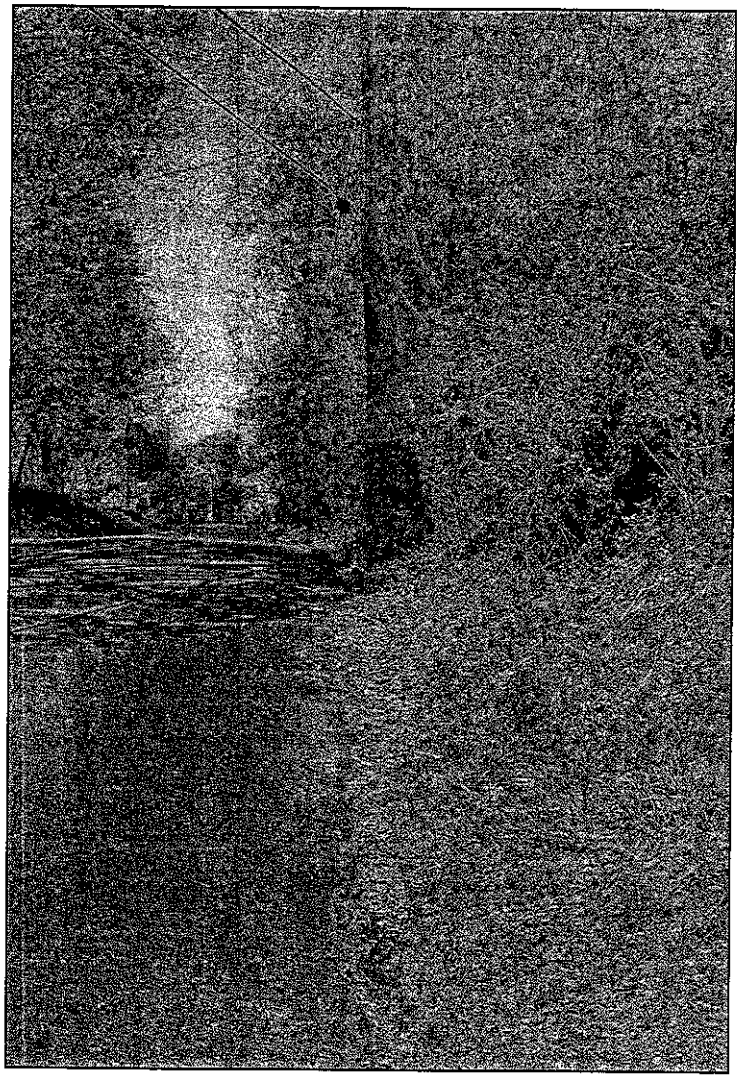


Figure 4: Erosion along poorly maintained side ditch, High Street, Waterford, VA. [Source; Author, 2003]

water run off causing damage to the functional and contextual environs of villages and historic districts.

Improvement Impacts: Water Runoff

Ineffective road drainage is the most frequent cause of road deterioration. It permits water to erode and undermine the road's base, leading to pavement cracks that allow water to penetrate the structure, promoting surface distress and failures that increase with time and traffic, and eventually requiring repaving. In Waterford, Virginia this cycle has been repeated five times since 1937.

Ill-maintained drainage systems suffer from increased erosion to their pathways with every passing storm, compounding the effects of storm runoff, increasing the silting of ditches, clogging of culverts and deposits of debris along curbs and gutters, and disrupting the flow of surface water along natural outfalls to creeks and rivers. Where the water then goes leads to countless consequences for the natural and built environments of villages and historic districts.

Improvement Impacts: Natural and Built Environments

Besides sediment and debris, errant run-off also carries pollutants beyond the road edge, where they then contaminate and damage the natural environment. Ground water, plant and animal habitats and the aquatic environment of ponds and creeks are all susceptible to adverse affects from pollution. Particulates from tires, brake dust, exhaust emissions and de-icing chemicals all have damaging consequences for the roadside ecology. Suspended in run off, their potential to contaminate ground water, alter soil composition and the exchange of nutrients, adversely affect plant and animal habitats and

can spread well beyond the road edge. The same particulates are carried by air currents, excited by passing vehicles, even further from the roadway, posing health risks to residents and an even wider segment of the natural environment.

The built environment is threatened as well by uncontrolled moving water. While all buildings and materials decay over time, the degree and rate of their decay is a function of the reactions and interactions they experience with the conditions specific to their environment. Given that water is the primary cause of most building deterioration problems, buildings and structures beside roadways where uncontained run-off can flow, collect or puddle, are at risk for accelerated damage to their structures and material components, especially those of older buildings that have experienced the long-term effects of an erosive environment.

There is an endless list of possible permutations to the properties of building materials and systems that can then affect their performance. When the environmental conditions under which the otherwise stable properties of a building material are exceeded, deterioration will occur. Buildings can settle, crack, bulge and given enough time, even collapse from the damaging effects water can perpetrate against them. An example or two of how buildings deteriorate when their components are exposed to excessive amounts of water will aid understanding the building impacts discussed in the case study of Waterford, Virginia.

Because water expands when it is heated or cooled, and may be transformed from a liquid to a vapor or a solid depending upon temperature and water's ability to migrate hydroscopically through capillary action, it will promote decay of building materials, when it is excessively present within them. Water that reaches the facade or foundation of

a building may flow into a crack or crevice of its surface, where depending upon the time of year; temperature and specific conditions, may remain, evaporate or freeze, initiating the process of deterioration. For instance, a masonry building constructed with a brick facade, typical of many buildings cited in the case study, will develop symptoms of water damage once an inordinate amount of water is present within its component materials.

Most insidious, is the process called rising damp. What happens is that water migrates through the brickwork. It first enters a breach in the surface materials, remains in the brick and mortar, and is augmented by additional wettings. The water then rises through capillary action to levels beyond the actual point of infiltration. With a sympathetic environment, frequent wetting and drying, and repeated freeze – thaw cycles, this condition will exfoliate the face of brickwork, render its pointing into crumbled bits of mortar, and continue to undermine wall stability until the causes of the symptoms are remedied.

Wood, a material present in all the buildings of the case study, also is prone to deterioration from excessive water. Fungi and wood-destroying insects are attracted to moist, warm environments with an adequate oxygen supply, conditions they require to begin the process of decay. Errant road run-off will deteriorate wooden building materials and components by physical, chemical or biological action.

Buildings are designed to protect residents and their belongings from the natural elements. Wayward water moving toward their envelope upsets what otherwise (if all else is maintained) would be considered a healthy building environment.

The various ways in which run off can affect the landscape and building environments is a kaleidoscope of interrelationships formed between fixed conditions and

external forces. How they materialize is explored in chapter four, a case study of Waterford, Virginia.

Improvement impacts: Pavement Layers

From the author's research, it is apparent that road paving without the benefit of proper design and maintenance has led to the need for road surfaces to be repaved an inordinate number of times in rural communities, resulting in pavement heights that thwart proper drainage. Waterford's five layers (first layer 1937, last layer 1992) of paving measure ten inches in thickness above the original dirt road. If the present average of two inches every eleven years were to continue, by 2025 the pavement will be sixteen inches above the original roadbed. It is also evident that sporadic maintenance of road drainage systems has created problems that then metastasize beyond the road edge into areas of the natural and built environments that can further harm elements of the landscape.

Many rural road grades have reached a point relative to their side drains where they can no longer simply be re-paved to renew their surfaces without first milling off a portion of the old surfaces before applying another layer. The slopes of drainage paths remain in continual need of re-dressing after the rushing water from thunderstorms remove the traces of previous maintenance repairs. The cycle is unending. Within rural historic districts the problems are acute.

Rules, Regulations and Review

Roads have a long-standing history of rules and regulations, specifying how and where they were built that underscore their importance to the functions of our society and

economy. As early as 1632, the House of Burgesses, twenty-five years after Virginia's first permanent settlement was established, adopted America's first road legislation. Recognizing the need for roads and their improvement, it called for, "in the language of the day that, 'Highwayes shall be layd in such conveinient places as are requisite accordinge as the Governor and Counsell or commissioners for the monthlie corts shall appoynt, or accordinge as the parishioners of every parish shall agree.'"[67] Going on four centuries now, road laws and regulations have been amended, expanded and rewritten in response to the needs and requirements of the country to accommodate and direct growth and development.

Between 1794 and 1878 there were twenty-eight road cases recorded in the Loudoun County Clerk's Office relating to roads and bridges leading to or in the vicinity of Waterford. Typical of their granting language were requirements to clear no less than a thirty-foot right-of-way, for a road no less than sixteen feet in width and having a grade not to exceed four degrees of slope. These same requirements describe many of the roads within the state's secondary road system. " One of the few constants between Virginia's early country roads and the modern secondary system is the thirty foot road width now manifested in the presumed thirty foot prescriptive easement for secondary roads. A statutory 30- foot width harks back to one of the first extensive pieces of Virginia road legislation, passed in 1705."[68] While secondary road regulations have retained their right-of-way width, many other elements of their alignments have evolved to alter their character, but nothing like those of our primary roads.

Modern roadway standards profoundly affect not only the physical character of our communities and landscape, but our quality of life and the environment as well.

Federal regulations apply to all roads within the National Highway System (NHS). States receive $8.00 from the Federal Government for every $2.00 they spend on transportation projects. For its contribution, the Federal Government requires the States to comply with guidelines developed by the U. S. Department of Transportation (DOT) and the American Association of State Highway and Transportation Officials (AASHTO). The guidelines, *A Policy on Geometric Design of Highways and Streets*, better known as the "Green Book," contain the latest practices in use as the standard for highway geometric design.

Congress reauthorizes the federal-aid highway program every six years. The Transportation Equity Act for the 21st Century (TEA-21) enacted in 1998, delineates how funds are to be allocated between new construction, maintenance and transportation enhancements. All road projects receiving Federal funds require review of their environmental impact as defined in the National Environmental Policy Act (NEPA). There are a few Federal statutes that can initiate cultural and historic reviews as well. If a project may affect publicly owned land or historic resources, Section 4(f) of the Department of Transportation Act requires environmental or historic reviews. The statute requires highway projects to avoid public lands and historic resources unless there is no prudent and feasible alternative, and mandates use of all-possible planning to minimize harm to the resource. Section 106 of the NHPA delineates a broader scope of protection that requires all Federal agencies to consider the effects of their undertakings on historic properties and seek ways to avoid, minimize or mitigate any adverse effects to them. All other roads are subject only to state standards, "Projects other than NHS roads shall be designed, constructed, operated, and maintained in accordance with State laws,

regulations, directives, safety standards, and construction standards,"[69] unless they also receive federal funding.

The Virginia Department of Transportation (VDOT) is responsible for all primary and secondary public roads in the state, except for those within cities and incorporated communities with a population greater than 3,500 people. Though not required by law, VDOT subscribes to AASHTO standards for guidance on the management of all roads within its system. While there is design flexibility in AASHTO's *Green Book*, allowing "a range of acceptable values for various aspects of road design, depending on conditions,"[70] VDOT tends to follow the most conservative interpretation of these guidelines. VDOT has acquired a reputation for being an extremely conservative, inflexible organization with a tendency to overlook public sentiments, instead spending its bureaucratic energy and federal funds primarily on building and widening roads, and have little patience for context-sensitive solutions that respect communities' natural and cultural resources.

Unfortunately, this institutional attitude creates conflicts with county governments trying to direct context-sensitive improvements to local roads. Loudoun County's Countywide Transportation Plan illustrates the problem: " VDOT has design standards for the wide variety of secondary roads that exist in Loudoun County ranging from rural local roads to subdivision streets. However, as the County developed policies to encourage creative forms of residential development and the public demand for preservation of the character of the County's unique rural roads grew, the strict application of VDOT standards has caused problems and frustration...There is strong support in the County to modify VDOT standards for roads in the Rural Policy Area in a

manner which is sensitive to the rural character."[71] This difficulty in finding reasonable alternatives to VDOT's one-size-fits-all approach is echoed throughout the County's Transportation Plan.

The Plan also notes VDOT policies that restrict how maintenance funds are to be used. Suggesting their revision would allow, "More flexibility for spot improvements as opposed to having to improve a longer section of road via a large Secondary Road Improvement Project."[72] Despite the concept of "Fix it First," recommended in TEA-21 for NHS projects, AASHTO's guidelines for 3R Projects, (resurfacing, restoration or rehabilitation), or the "pave-in-place" standards authorized the by the State legislature, VDOT's lack of a creative vision, its inflexible bureaucracy and conservative approach have led, with a few exceptions, to over-engineered community roadways, instead of the context-sensitive designs sought by communities and recommended by governments.

These conclusions are supported by two reports. One produced by the National Trust for Historic Preservation, *Virginia Policies That Contribute to Sprawl: An Agenda for Change*, reviewed the planning and transportation policies of the Commonwealth of Virginia. The report strongly criticizes VDOT stating, "As a general rule, they favor road construction and widening at the expense of historic resources, cultural landscapes and natural resources."[73] The other report, produced by the Surface Transportation Policy Project, a non-profit national organization devoted to transportation policy reforms, found that over a ten-year period (1992-2001), Virginia spent the smallest (13.4) percent of any state of its federal-aid highway funds on road repairs and rehabilitation. "As of 2001, nearly two-thirds of Virginia's roadway miles were found to be in poor, mediocre, or fair condition. Yet despite the obvious need to repair existing roads, VDOT instead dedicated

almost 41 percent of the state's available federal funding to the construction of new roadway capacity."[74]

VDOT's resistance to adopt a more flexible approach to its management of the state's roadways ignores DOT's support for context-sensitive design that has existed since the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991. Its successor bill, TEA-21 increased the funding and support of transportation policies for community preservation objectives. And DOT has explicitly encouraged accomplishment of those objectives in its guidebook *Flexibility in Highway Design*. The guide restates Congress's commitment to safety and mobility, while emphasizing the need for, "preserving and protecting the environmental and cultural values affected by transportation facilities."[75]

The reluctance on VDOT's part to acknowledge the changing nature of how road improvements and their maintenance can successfully be integrated with the public's desire to retain their sense of place is problematic. At its core is the issue of control. It is relatively easy to build something new, where one has nearly complete control of all the variables of a project. It is a completely different case when the conditions are already set and a project must consider the public's concerns along with the interfaces between old and new and the potential for adverse environmental consequences. VDOT's perspective, is myopic, a carryover from times past, when the engineering of roads blindly focused on safely moving the greatest number of vehicles along the roadway and little more. Applying highway standards to secondary roads located where most of the population lives and works is inappropriate. To reconcile this conflict between over-engineered roads and the public's desire to retain a sense of place requires satisfying both the

requirements for safe passage, and consideration for the cultural, historic and environmental elements of the roadway environment.

Given the approach VDOT has pursued over the decades for road improvements, it is fortunate the roads of rural historic districts were paved without the benefit of a designed system. Although the manner in which secondary roads have been maintained has damaged their built and natural environments, the damage is correctable. Whereas a designed road system may have erased beyond recovery all vestiges of the evolved roads of historic districts and their cultural integrity, VDOT's steadfast focus on new construction has allowed most of Loudoun County's rural roads and those of historic districts to remain unchanged, save for multiple pavings, while they simultaneously deteriorated; essentially, they have been preserved through neglect.

The following chapter, a case study of Waterford, Virginia explores the impacts of this neglect. Waterford, a National Historic Landmark where the author resides and has plied his trade as a restoration contractor for the past quarter century, presents numerous examples of what can happen after the rain.

CHAPTER IV
WATERFORD VIRGINIA: A CASE STUDY

This case study investigates how the paving of roads in the National Historic Landmark District of Waterford, Virginia has affected it, and its relationship with its environment, from the time paving was first introduced to the present. The age of the district's building stock and the integrity of its cultural resources present a contextually rich pallet for investigation of the effects of paving on the district's historic resources. The study will provide the data for analysis, and assist in understanding and defining the relationships that have developed since paving was introduced. The study will produce findings that will inform future paving plans and methods to lessen detrimental effects and provide guidance to assure the continued preservation of the district and its fabric. Toward accomplishing these goals, it is important to set the historical context in which the district's roadways have evolved and define the characteristics that make them a significant contributing element of the district's history.

The District's History

Waterford, Virginia, is located in the northwest portion of Loudoun County between the Catoctin Mountains on the east and the Blue Ridge Mountains on the west, in an area geologically referred to as the Piedmont Region. In 1733, Amos Janney, a Quaker from Bucks County, Pennsylvania in search of suitable farmland, purchased four hundred acres along Catoctin Creek, establishing the first settlement in Loudoun County

west of the Catoctin ridgeline. Ten years later, his wife's sister and brother-in-law, Francis Hague, moved to the area, purchasing an adjoining parcel of three hundred and three acres. Within these two parcels was the site of the future village. Soon thereafter, more Quakers settled in the area, clearing the land and starting small grain farming operations. Around 1741, Janney built a log gristmill on the western side of Catoctin Creek to service his farming operation, just across the creek from the site of the present mill. As the population increased and more land was cleared, a small group of houses and support buildings were constructed near the mill. With continued population growth the mill soon became the center of a thriving agricultural community. By 1744, there were enough Quakers in the area to form the Fairfax Meeting of Friends. They built their first meetinghouse, now a residence, on the northeastern edge of the settlement.

Mahlon Janney inherited the property upon his father's death in 1747. By 1762, a new mill was needed to accommodate the continued growth of the farming community. Mahlon's new mill was made of wood with a stone foundation on the site of the present mill. This new mill had a millrace that gave the miller more control over the flow of water and some protection from flooding when the creek was swollen from heavy rains. During the same period, the land alongside Main Street, from the mill, to what is now the town center, was divided into building lots. Scotch-Irish artisans who arrived during this first period of expansion are credited with constructing many of the buildings that began the community's transformation into a village.

Waterford continued to prosper into the nineteenth century; in 1801 it was chartered as a town and by 1836 was incorporated. The economic well being of the community was rooted in a relationship of interdependence between the surrounding

farms and the village. By 1818 the village had reached its present boundaries, though it would be decades before streets and lots were fully developed (Fig. 5).

Many homes were also commercial establishments, with living quarters above, that satisfied most needs of the community. The Loudoun Mutual Insurance Company was formed in 1849; it is still conducting business and is the largest employer in the village. The Loudoun County Bank was founded in 1815; it was housed on Main Street not far from the mill, in a house now called "The Bank House." There were two additional mills built during this period on the south end of town that provided wool fulling, processed lime for fertilizer and mortar and milled lumber.

The Civil War brought turmoil and division to the community. The Quakers' belief in non-violence and their opposition to slavery were in direct conflict with slaveholders in the area and the Confederacy. Though there were a few skirmishes as Confederate and Union troops moved through the village, the restrictions on trade and travel were more disruptive than the battles, because they created difficulties in distributing produce and obtaining supplies. There was little of strategic importance in western Loudoun County other than mills supplying flour and grain to Washington, and farm animals and crops, which were often stolen or destroyed by the armies of both sides.

For a brief time after the war, Waterford returned to normal, and its prior development resumed. However, in 1870, as the railroad lines were expanded, Waterford was bypassed. The village that before the Civil War was the second largest town in Loudoun County, and served as the commercial center for farms within an eight-mile radius, slowly fell into decline. The railroad's alignment passed three miles south of Waterford, re-directing the trade and growth those earlier transportation routes had

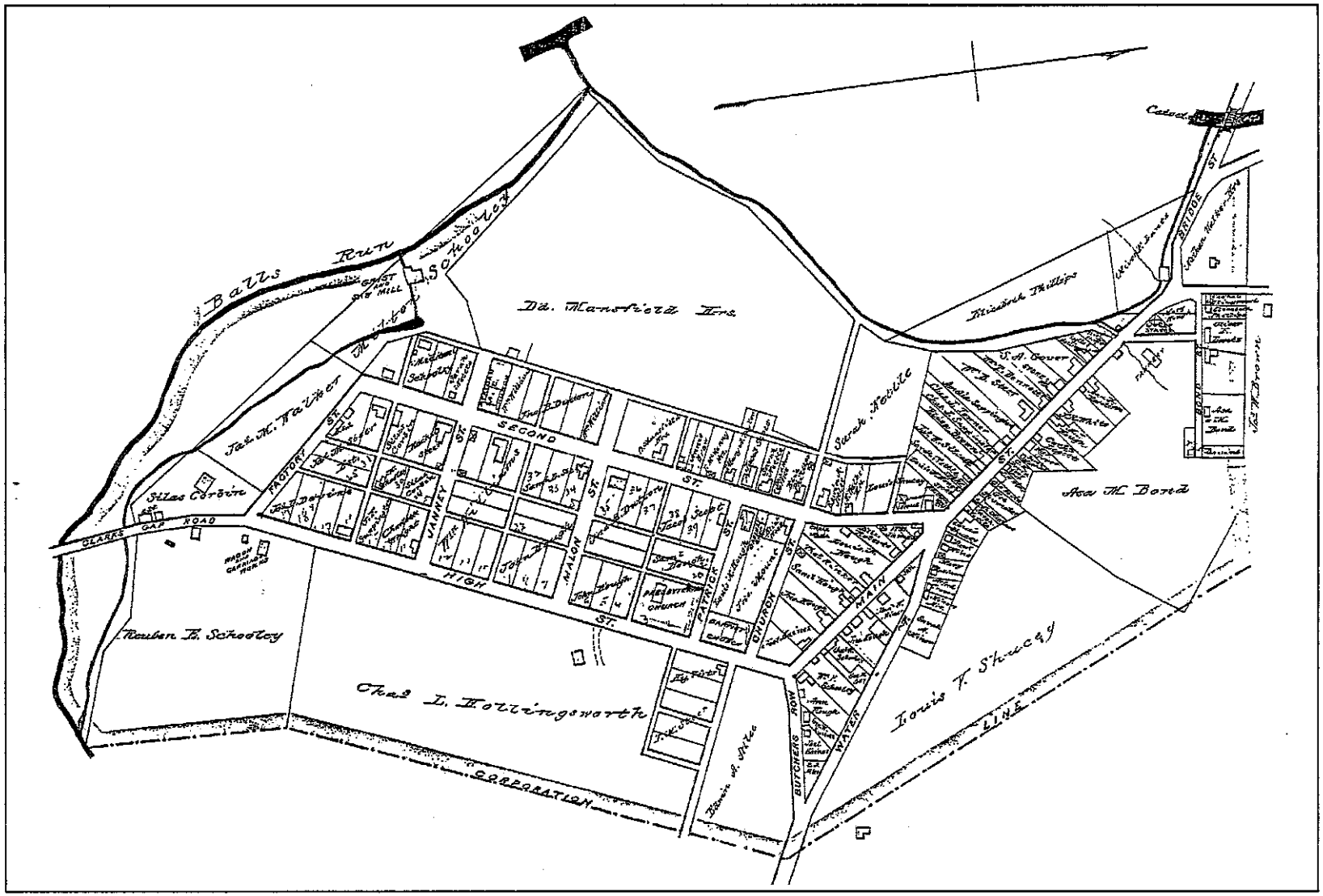


Figure 5: Waterford, 1875. [Source; Waterford Foundation Archives]

directed through Waterford. Towns along the railroad continued to grow, and over time became the new commercial centers, while Waterford's once abundant commerce receded. The wares of Waterford's craftsmen were unable to compete with the mass-produced goods transported by the railroads; one by one they went out of business. As the once prosperous village experienced economic decline, residents moved away to find employment elsewhere.

Though it has been inferred that the railroad's alignment may have been retribution for Waterford's pro-Union leanings (in 1861 the Waterford precinct rejected secession by 220 to 31 votes), the more likely explanation was business economics. Natural topography and the most economically feasible way to reach their destinations strongly influenced the alignment railroads followed. Waterford was simply not along that pathway. Waterford's distance from the railroad assured its continual decline through the Great Depression, thereby preserving its historic character to be resurrected during another period – after its roads were paved.

During the 1930s, Federal programs relating to historic preservation were enacted. In 1933, the National Park Service used New Deal funds to create the Historic American Building Survey (HABS), employing out-of-work architects, historians, writers and artists. In 1937, the same year Waterford's roads were first paved, an HABS survey of Waterford recorded a village of deteriorated and dilapidated buildings. The Federal Writers' Project was another New Deal program designed to produce comprehensive guidebooks to each state's history, architecture, culture and commerce. These programs and hard surfaced roads were instrumental in the rebirth of Waterford. New residents

interested in Waterford's historic character, old buildings and small town living began moving into the village, restoring houses.

The Waterford Foundation was formed in 1943 by a group of village residents with the objective of preserving the village. They raised funds for this purpose by sponsoring a crafts fair each year. With the proceeds, they purchased and maintained many of the defining nonresidential buildings of the village that would have otherwise deteriorated from neglect. In 1970 the Department of the Interior designated Waterford and its surrounding farmland a National Historic Landmark District. As development pressures have increased over the years, the Foundation has expanded its goals to preserving and protecting the farmland surrounding the village through easements and outright purchases to retain the visual and cultural legacy of the landmark.

Road Development and Evolution

To walk along Waterford's streets, less than fifty miles from our nation's capital, is to pass through remnants of nearly three centuries in the evolution of what began as a remote agricultural settlement on the frontier of a young nation. Settled after the Treaty of Albany restricted Native Americans to the regions beyond the Blue Ridge Mountains, Waterford experienced many of the events associated with our country's development to become by happenstance an artifact of our nation's heritage. Ironically, Waterford's decline after the Civil War is what allowed much of its natural and cultural fabric to remain intact and unaltered by development.

The village's natural topography includes steep hills along its eastern and northern edges, falling to a lowland plateau. The plateau, which curves crescent-like just

above the wide floodplain of Catoctin Creek, is where the settlement developed (Fig. 6). Along this plateau, the village grew steadily for one hundred years, as paths leading to and from the mill became the roads that by 1818 defined the village's present day layout.

Settled during a time when the only means of transport available was walking, horseback or horse-drawn wagons, Waterford's roads have a distinctly human scale. The roads within the village were not so much built as evolved through necessity, their grades and direction being defined by the natural topography. In present day terminology they would be defined as "cultural roads," meaning as the needs of the community grew, they evolved in an organic, adaptive manner over time, rather than being designed and engineered to generate or aid development.[76] For nearly two hundred years they remained unchanged except for gravel dressings and routine maintenance, until they were hard-paved during the 1930s.

Parcel Divisions

Four land subdivisions between 1782 and 1812 demarcate the road alignments, lot divisions and village boundaries that exist today. The first of these to be marked out for building lots was along the north side of Main Street after Francis Hague died in 1780. The second sub-division was recorded in 1792, when Mahlon Janney divided his holdings along the south side of Main Street into fifteen building lots. These two divisions extended the settlement from the mill and Bond Street, along Main Street toward the present village center. Shortly after, in 1804, the third expansion occurred when Main Street was extended eastward up the "Big Hill," and the adjoining land was divided into seventeen building lots. The last section was plotted in 1812, on land owned

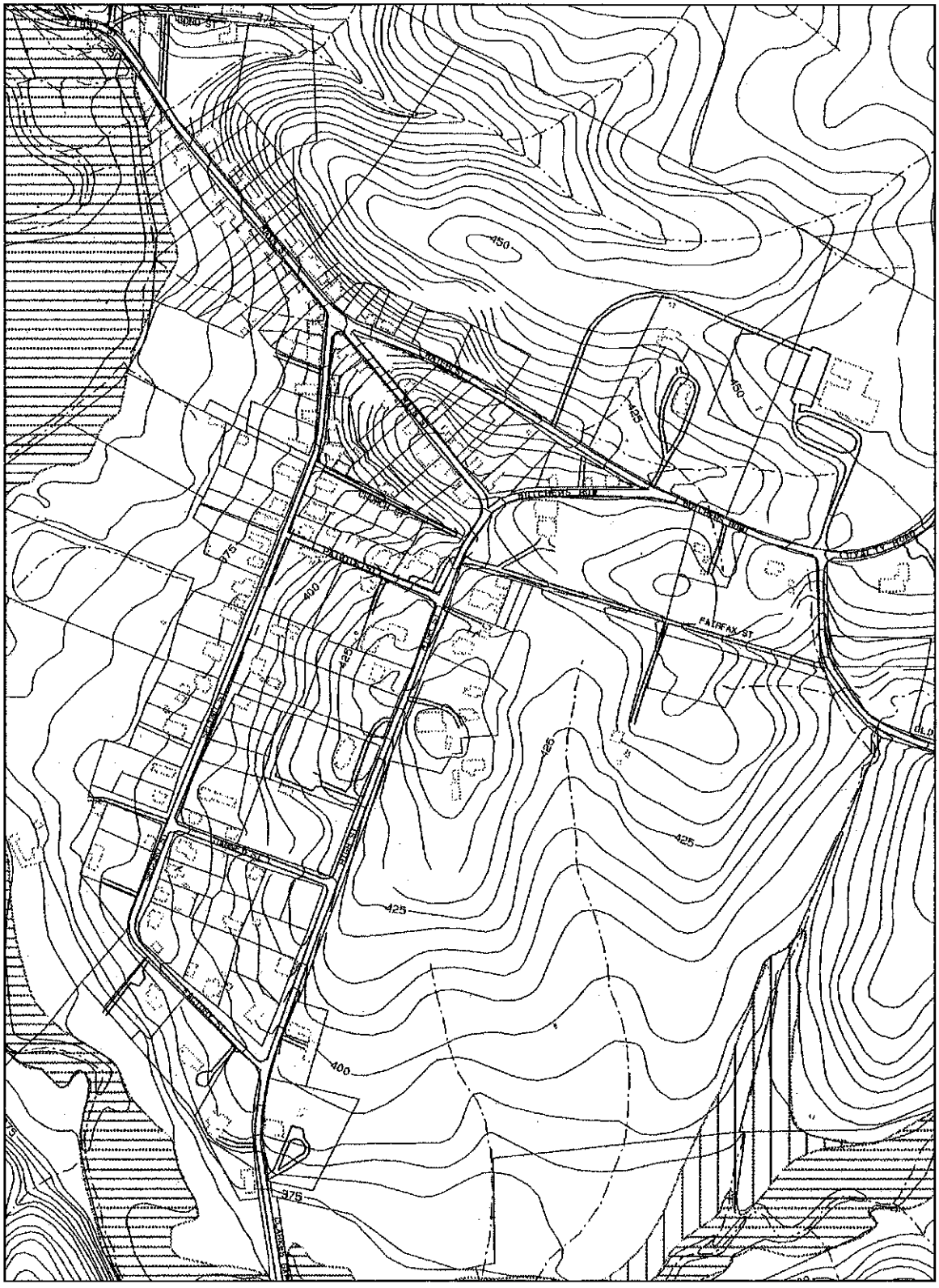


Figure 6: Topography of Waterford. [Source; Loudoun County Office of Mapping, 2002]

by Mahlon Janney, and referred to as "New Town." It contained sixty-four lots, encompassed by Second Street and High Street on the west and east and by Patrick Street and Factory Street on the north and south.

An observant stroll through the village in the order these parcels were divided into building lots reveals distinct spatial characteristics that show both adaptations to the natural surroundings and the progression of growth and development Waterford experienced during this time. They are marked by variations in the relationship between adjacent properties, lot sizes, building lines, sidewalks and the road edge. There are also physical differences in building sizes, architectural style, and the types and methods of construction within each parcel that further display Waterford's steady rise to prominence over its first one hundred years. However, Waterford's development was far from linear. While there are consistencies to these areas, there are also many examples of later style and types of construction within each, some of which were in-fill, and others replacement buildings or additions. Though the built environment continually evolved and changed, the spatial organization adopted when these land divisions occurred has remained intact.

Edges

It is beside the road edge, where the private meets the public, that differences are apparent. Though the widths of through streets and cross streets are surprisingly consistent throughout the village, the right-of-way incrementally expands the further one travels beyond the mill. Variations appear in the spaces between the road edge, shoulder, curb, sidewalk and houses. Main Street's parcels have the earmarks of an earlier traditional village, with spatial qualities that imparts an intimate scale to its streetscape

and buildings. At the same time, the structures on lower Main Street show an awareness of the spatial constraints faced in building on this narrow strip of land between the steep hillside and flood plain to achieve a functional space.

Main Street had been the pathway to the mill for nearly forty years before its bordering land was divided into building lots. The houses built along its sides are generally smaller, closer together, with some in rows, similar to those found along the streets of early colonial settlements, than the homes found on later parcels developed in the village.

Along Main Street's north side, where the hillside descends to a flat, houses were built into the hillside and sit five feet or more further back from the road edge than those found along the south side of the street. The difference in the building setbacks may be attributed to lot topography, specifically site access for construction purposes, while not interfering with the public way. Construction on the north side of the street left little space to work without overflowing into the street; the additional five or so feet beyond the sidewalk edge allowed a margin of access for building. In contrast, houses built along the south side of the street could be constructed to the sidewalk edge without the site constraints of their neighbors across the street, given the spaces behind their buildings used to effectively work the sites.

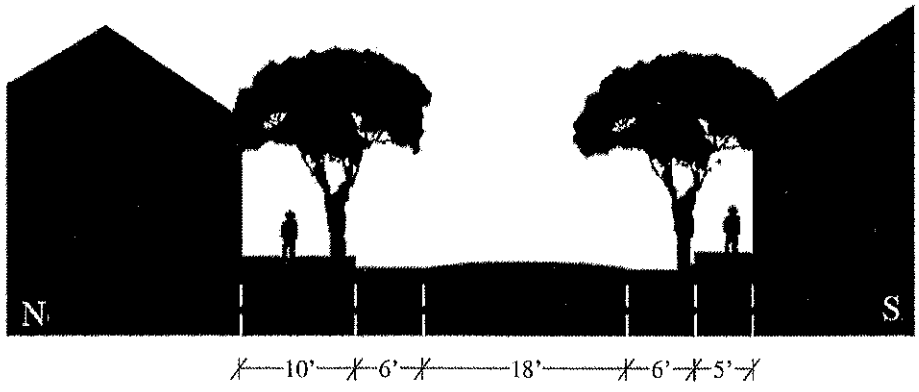
In tempo with the rising agricultural economy in the first half of the nineteenth century, Waterford's fortunes and environs expanded to the land east and south of Main Street, the subdivision of land generally following the same pattern and scale already established. During the span of twenty years following Main Street's division, the number of plotted lots within the village increased by two hundred and fifty percent,

evidence of the prosperity and pace of growth enjoyed by the community during this time before the Civil War.

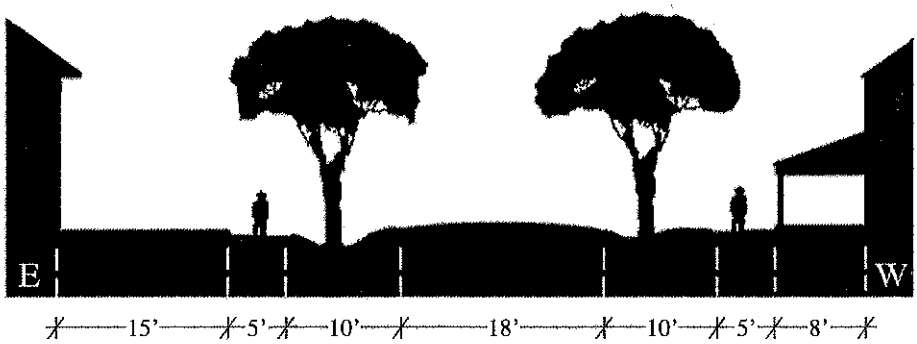
The present-day building stock of the village still reflects this period of prominence. Sixty-five structures are pre Civil War, and represent nearly two-thirds of the present day building stock. Of the one hundred nine buildings standing in the village today, seven are from the last decades of the eighteenth century, eighty were built in the nineteenth century and twenty-two more were added during the twentieth century.

As the village expanded, so did building lots and houses, though the more notable changes to occur are found along the strip of ground between the road edge and building lines (Fig. 7). Differences abound throughout "New Town" with respect to building setbacks, sidewalks, curbs and gutters, drainage ditches and shoulders. New Town was the last and largest parcel sub-divided and only reached build-out sixteen years ago. This length of time, one hundred seventy six years from inception to full development, may account for the variety of spatial relationships found there. For instance, the last house built on a vacant, available lot, was constructed in nineteen eighty-eight, its siting reflecting ordinances that didn't existent when most of New Town's development took place. Unfortunately, or at least interestingly, its setback seems to remove it from the sociability of the streetscape engendered by the spatial qualities of the village's earlier development.

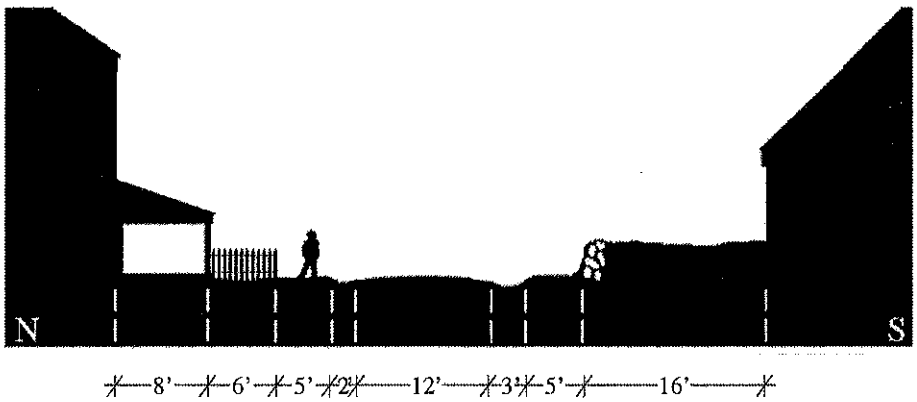
The differences in road edge treatments are best understood by examining the larger topographical and hydrological conditions of the village in concert with the specifics of each building site, their times of construction and any ordinances that may have existed. Most of these variations in edge treatment address storm water



1/16" = 1' Minimal Setback, Main Street.



1/16" = 1' Increased setback, "New Town", Second Street.



1/16" = 1' Narrow cross street, Patrick Street.

Figure 7: Waterford road cross sections. [Source; Author, 2003]

management. The village's mixture of steep hills and level to rolling terrain made for a variety of ditches, culverts, curbs and gutters to channel the movement of water over the ground for proper drainage from roads, away from buildings and toward the watercourses leading toward the creek and recharge areas.

Sidewalks were also a component of the space along a few streets. Long before paved roads, though limited, they were the only mud-free pathways through the village. Section Two of Town Ordinance Number Eleven adopted in 1875 directed, "That the sidewalks of all streets which are or shall be graded, shall be paved or planked with such material as the Council may direct."[77] Late nineteenth century photographs show brick sidewalks, but it is unknown when or of what the first sidewalks were constructed. Main Street is the only street with sidewalks on both sides, except for a very short section on the east side of Second Street that also connects to the only sidewalk on an uphill cross street. Patrick Street's sidewalk leads to the schoolhouse and churches of the village on High Street and may be the reason for it being there. There is a continuation of the south side sidewalk of Main Street along Second and Factory Streets that traverses, but for a few now missing sections, the entire village from the Mill to its southern edge. There are no other sidewalks in the village.

Presently, Waterford may be defined by its relatively unchanged landscape, which played a fundamental part in determining its pattern of settlement. Its roadways are an essential component of how that pattern materialized. The introduction of paving during the 1930s was the first infrastructure improvement to occur in its environs. Paved roads would alter the community's long established balance between its natural and cultural environments due to their physical nature and the accompanying economic and social

enhancements they would deliver to the village and its residents. The unfortunate paradox is that progress is often a contradictory improvement.

Present Day Condition of Waterford's Roads

Most all of Waterford's roads are now paved, although there remain a few examples of unpaved road surfaces. Before discussing the paved roads, it is instructive to note the few dirt and gravel roads still extant.

Dirt and Gravel Roads

Fairfax and Church Streets are examples of what the village's roads initially were – dirt ways, across the natural grade, with little or no surface improvements beyond that acquired over time through their compaction from passage (Figs. 8&9). Church Street, though passable, is no longer used and by any measure would be considered abandoned. In previous times it provided access from Second Street to High Street beside the Baptist Church, but is now essentially a pipe stem driveway for a residence constructed in the 1970s. Fairfax Street remains nothing more than two dirt strips leading from High Street past the town cemetery to Old Waterford Road, the original and still gravel route, between Leesburg, the county seat, and Waterford.

More recent reminders of Waterford's past road types are the gravel surfaces found on Bond, Liggett and a portion of Janney Street (Fig. 10). Though referred to as having been macadamized, neither they, nor any other road in the village, was actually built to MacAdam road design standards. Instead, they had gravel dressings applied periodically to their original surfaces. There was no excavation beyond the necessary shovel work to facilitate drainage within their pathways. Their gravel edges in many

Figure 8: Dirt road, Fairfax Street, Waterford, VA. [Source; Author, 2003]

Figure 9: Abandoned dirt road, Church Street, Waterford, VA. [Source; Author, 2003]

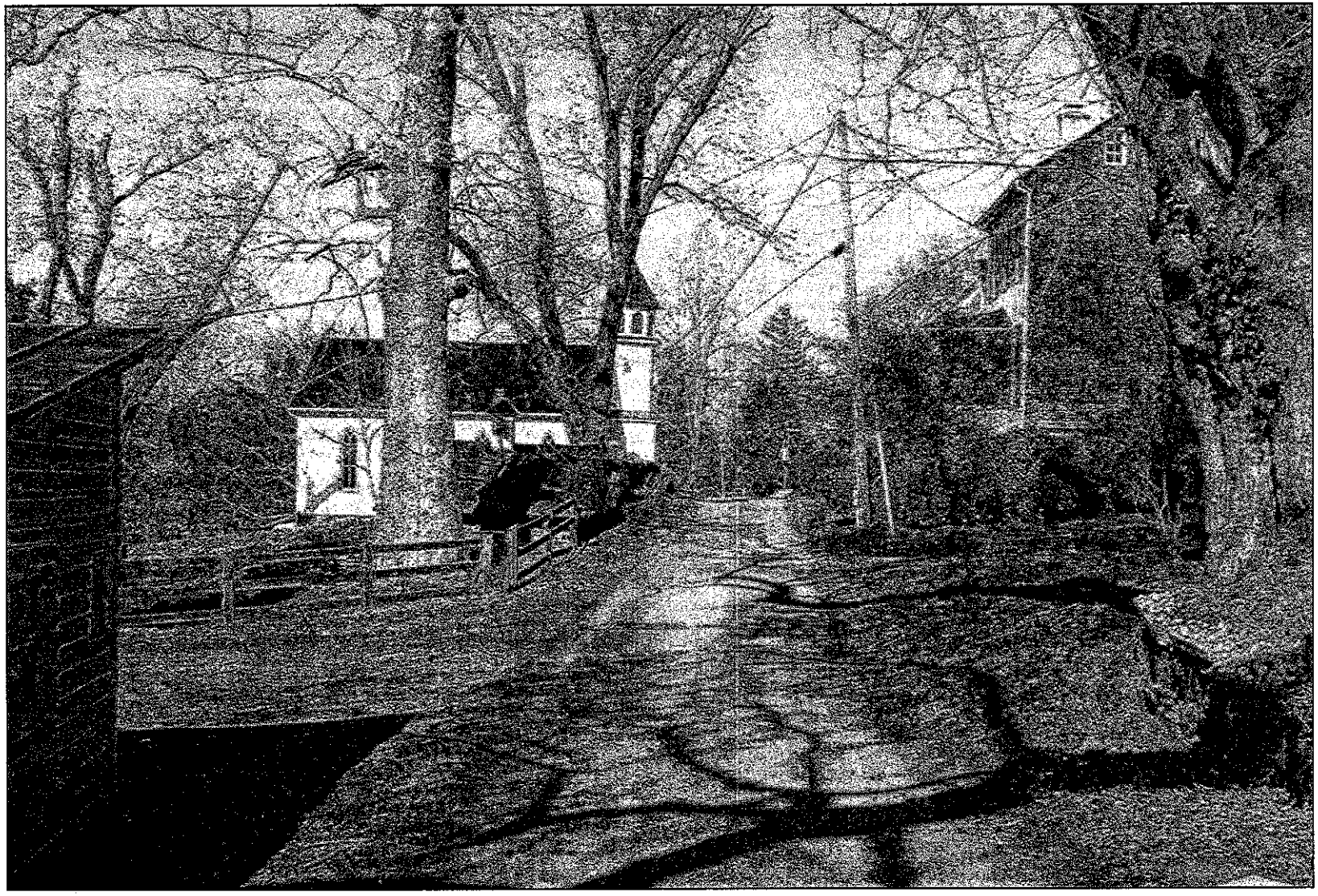


Figure 10: Gravel road, Bond Street, Waterford, VA. [Source; Author, 2003]

areas blend into the existing grade, as is evident from the washes of gravel and dirt found spreading through the grass at their sides like a lava flow. Where drainage ditches do exist, they often become catch basins for the gravel and dirt carried off the road by storm water run off after a heavy rain. At the same time, the buildup diminishes the capability of these ditches to function as intended, unless periodically cleaned out. Without a firm base of foundation stones contained within an excavated path, as MacAdam standards require, storm water quickly hits the compacted dirt below the gravel and moves along its surface because of the lack of sub-surface drainage. Depending upon the quantity and speed of the water, the top dressing of gravel can be carried away by the water to lower ground, leaving the roadbed once again exposed, muddied and eroded.

These streets are remnants of what all of Waterford's roads once were: either dusty or muddy pot-marked paths across the natural terrain. They were continually eroded by water, passage and the seasons, and made travel over them a questionable undertaking. Even today, negotiating them remains an adventure. Nevertheless, it is fortunate they endure, for they present examples of a time before paving and a brief glimpse of what living with such roads may have been like.

Paved Roads

This cycle of seasonal erosion and gravel dressings continued until Waterford's roads were hard-paved for the first time during the 1930s. However, because its roads evolved in phase with growth of the village, physical limitations to paving were posed. The road alignments and grades of curbs, gutters and sidewalks had been established long before guidelines or standards for paved roads were developed. In the same way that

gravel had been added to the roads' unaltered surfaces for decades, the paving material was placed on the existing gradients without any roadbed excavation.

Before Waterford's roads were paved, a variety of parallel ditches, some stone lined with curbs, had directed run-off to natural drainage channels that led to Catoctin Creek. Photographic evidence shows that curbs were added along specific sections of the roads, to alleviate drainage problems caused by additional layers of pavement, but there is no evidence of a comprehensive upgrade of the road drainage system. Instead, it appears that road drainage improvements were conducted in a piecemeal manner, without an overview of the functionality of the entire drainage system.

Some sixty years have passed since the first layer of gravel, embedded with tar was applied to Waterford's streets. Successive layers of paving have been added over the years, resulting in an accumulation of paving well above the height of the original roads (Fig. 11). In places, the multiple layers have turned curbs into scant protrusions and dramatically altered the flow of water across the landscape (Fig. 12). These conditions exist to varying degrees throughout the village; there are numerous places where even the most casual observer can see the physical effects. But the more subtle conditions are best observed during and after a heavy rain, as water following the pull of gravity passes through the town on its way to lower ground. The path water follows can be observed across the ground and into the basements of houses.

Waterford's steep slopes and undulating terrain is an inherently difficult landscape to effectively manage hydrologically. Runoff moving down its hillsides to the relatively flat to rolling ground that wraps around the flood plain presents numerous drainage problems. Although precipitation once turned the road surface into mud, paved

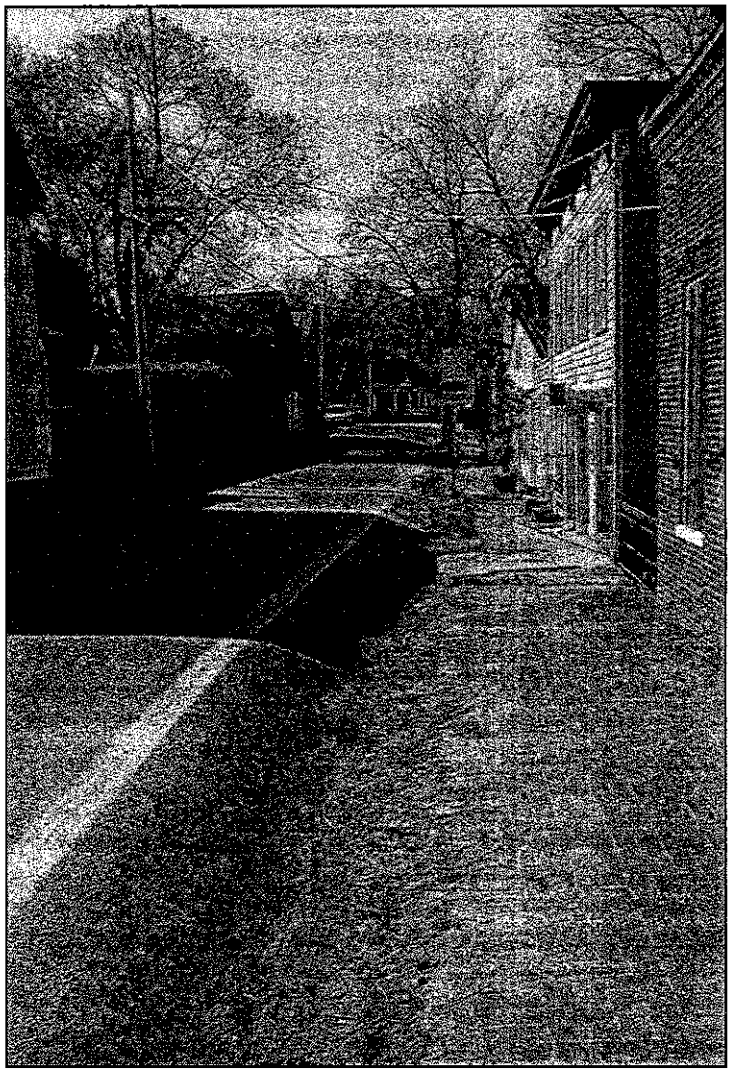


Figure 11: Heightened road, clogged gutter, Second Street, Waterford, VA. [Source; Author, 2003]

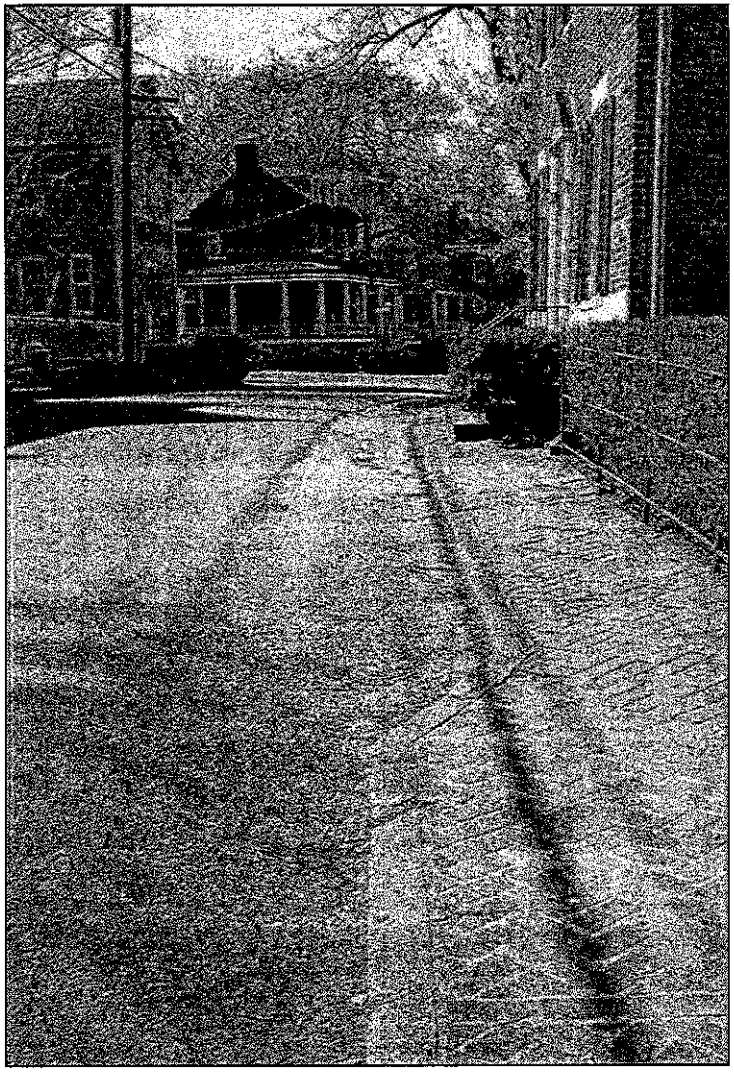


Figure 12: Partially buried curb, Second Street, Waterford, VA. [Source; Author, 2003]

roads compound runoff difficulties. Their hard, smooth surfaces increase both the volume and speed of run-off moving along their sides, resulting in increased erosion and silting of their drainage courseways. Pavement replacing mud was a welcomed improvement that re-directed the path of storm water and melting snows, but successive layers of pavement without proper drainage has created unintended consequences for the district.

The geometry of Waterford's roads as depicted in photographs taken before their paving has remained relatively intact. The through roads, Main, Second and High Streets, measure eighteen feet across, though from visual inspection it appears they were all somewhere closer to sixteen feet in width before being paved. As each new layer of paving was installed, their widths grew a little to better blend the pavement to grade, and with their side drains. The steep-sloped cross streets found between Second and High Streets have all maintained their original width of twelve feet, most likely due to the limited space originally allowed for the road and its drainage, leaving little space to spare within their rights-of-way.

The introduction of successive layers of paving on Waterford's roads, with the village's clearly defined rights-of-way separating private and public space, left limited areas at the road edges to address drainage. With each additional layer, drainage problems have increased. Culverts and water courseways once functional have become clogged and damaged from lack of maintenance. Each new layer of road pavement has been accompanied by an increase in the damaging effects of run-off and erosion to the district's landscape and historic structures.

Last year, an engineering firm conducting a traffic calming study of Waterford took seven core samples of the pavement; they averaged seven inches in depth, before

hitting a gravel base of stones two to four inches in size, suggesting that the original road-bed lay just below this gravel base. However, they were all taken on one side of the street, the side the sanitary sewer runs beneath. To remove any doubt of the pavement's true depth, the author hand-excavated the road edge opposite his house on Second Street and confirmed that the pavement is six and a half to seven inches thick and sits on a three and a half-inch base course of gravel consolidated with a bituminous binder. The original roadbed is ten inches below the road surface and consists of five layers (Figs. 13&14). The first layer is the consolidated base course, the second layer is a one inch thick slurry-like mix of small stones and a binder, and the last three layers are asphalt one and a half to two inches thick.

These findings confirm and quantify what is visually apparent. From the outset there were no formal plans beyond covering the soil with pavement for improving the rural roads in Waterford. This situation is not unique. The author's travels through Loudoun County's other rural historic districts, Aldie, Bluemont, Taylorstown and Goose Creek, found similar surface and drainage problems. It is apparent that the physical and contextual landscapes of rural roads were ignored for that which was most expedient. Multiple pavement layers have in turn led to adverse impacts to the environments of villages and historic districts. Maintaining the drainage paths of these roads would have extended the life-cycle of each layer of pavement, while lessening the degree of damage incurred by the fabric alongside and downstream of their outflows (Fig.15) Unfortunately, such preventive maintenance was ignored.

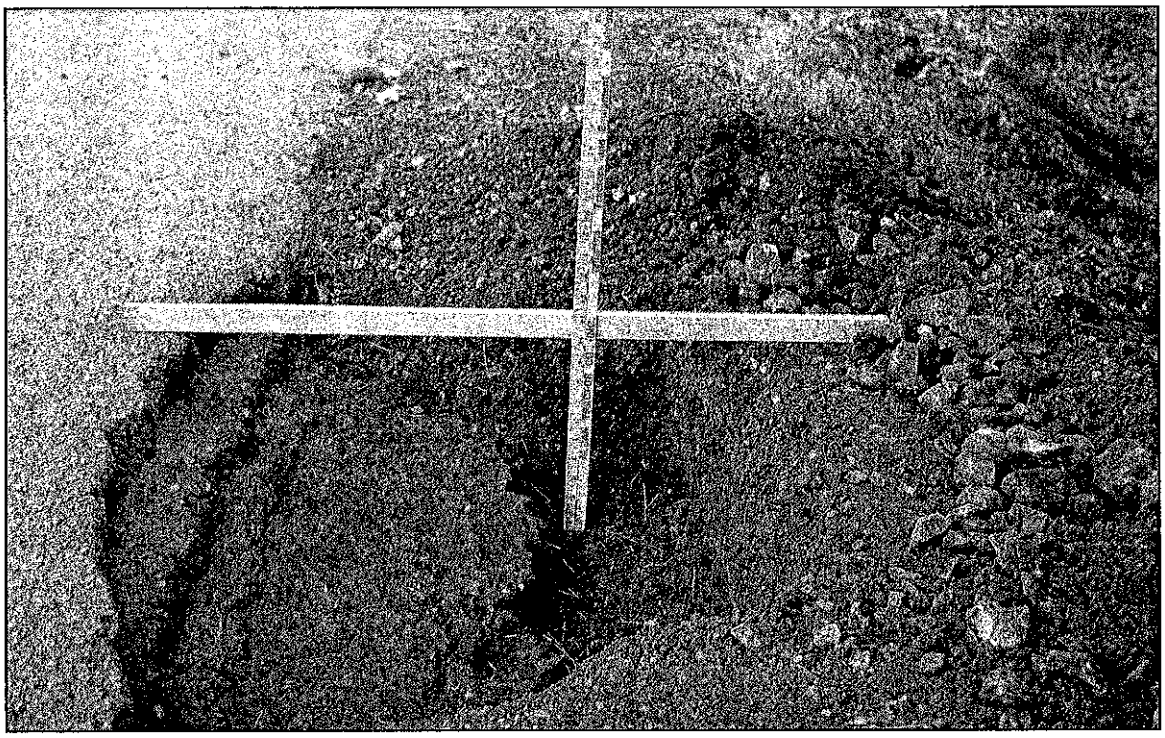


Figure 13: Original road bed 10" below existing road surface. [Source; Author, 2003]

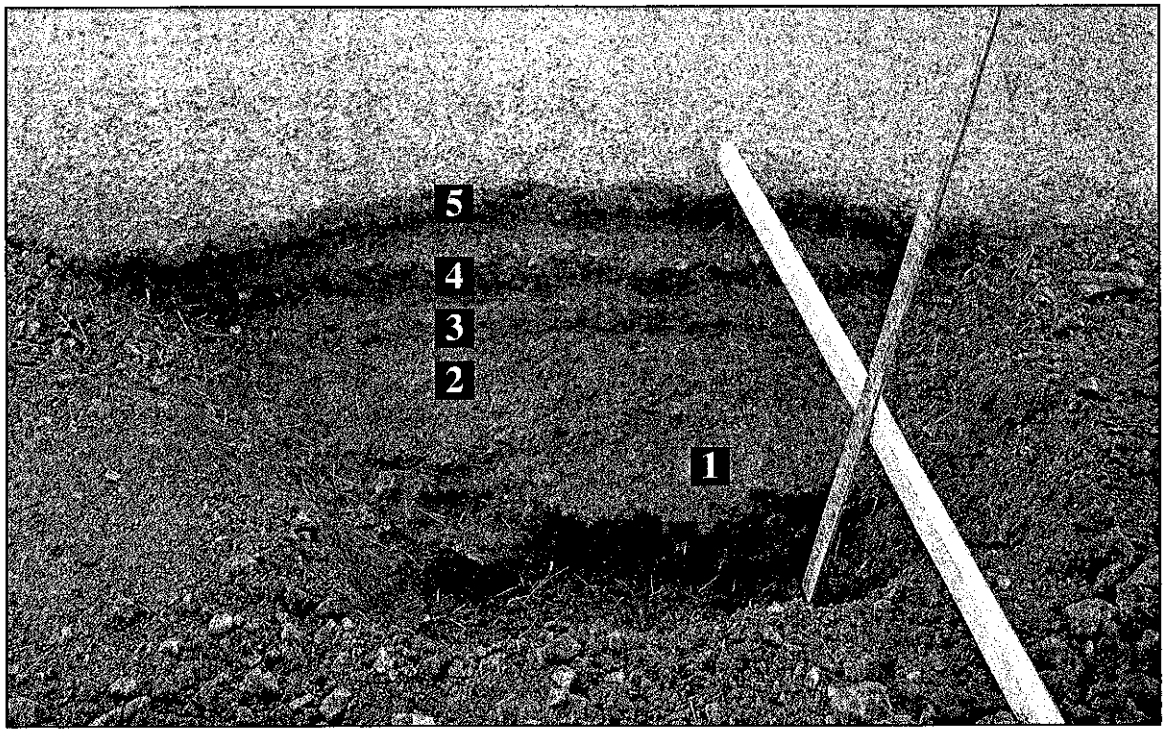


Figure 14: Five layers of pavement. [Source; Author, 2003]

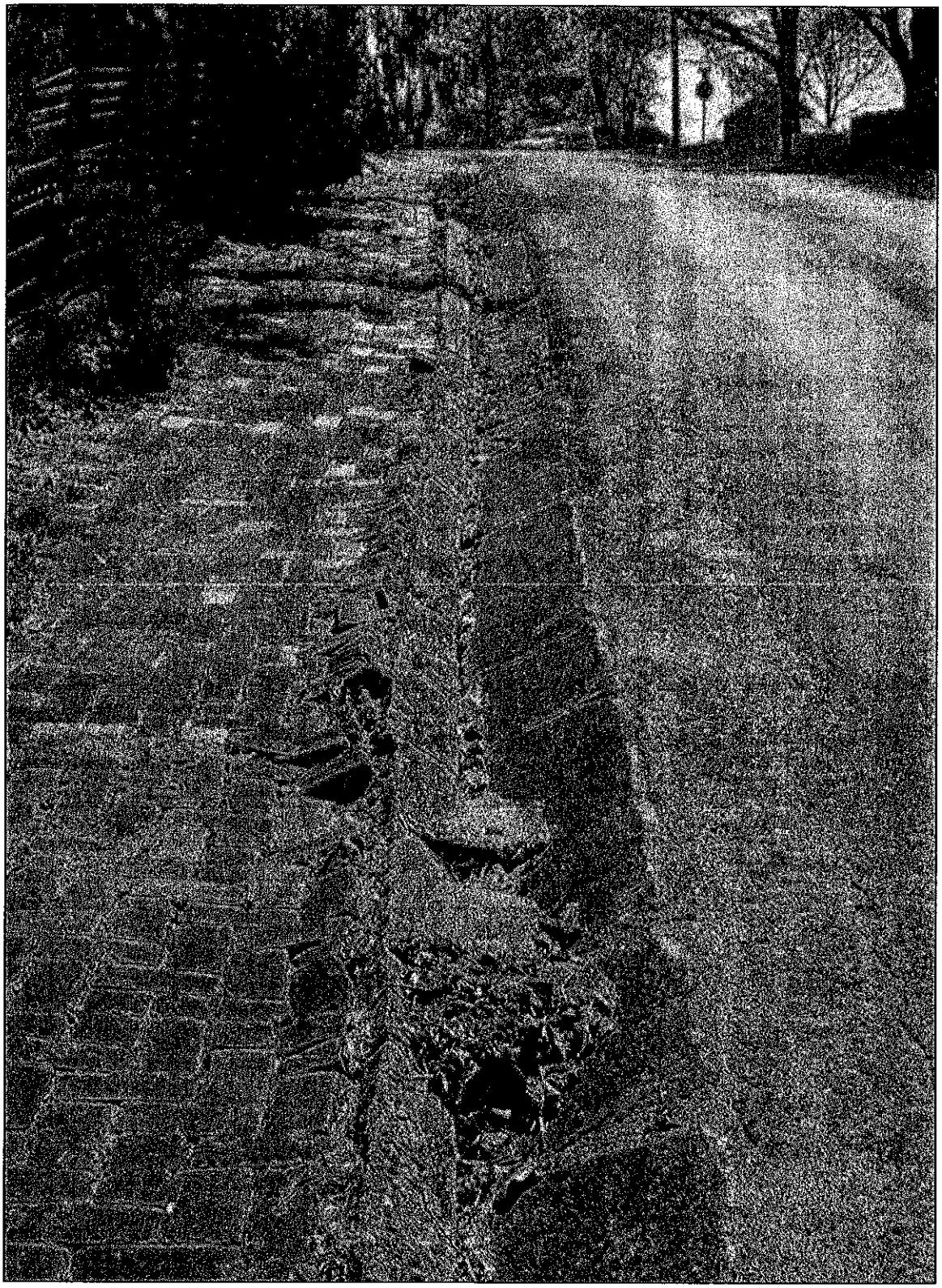


Figure 15: Deteriorated curb, gutter and sidewalk, Patrick Street, Waterford, VA. [Source; Author, 2003]

Impacts to the District's Fabric

The paving of Waterford's roads to varying degrees has contributed to impacts upon the district's integrity. The principal condition is an inadequate drainage system, a problem exacerbated by multiple layers of pavement that, when combined with rain, storm run-off and melting snow, results in erosion and deterioration of road edges from excessive amounts of uncontrolled water. As water travels beyond the road edges it threatens the cultural and environmental fabric of the district. Uncontrolled water thus is the major cause of material deterioration, building failures, and disruption of the roadside ecology due to the water itself and the pollutants it carries beyond the roads to the surrounding landscape. By analyzing these cause-and effect relationships, the present conditions and impacts can be more thoroughly understood, explained and comprehended. For clarity's sake it will be helpful to discuss in detail the conditions that are at the heart of the problems and their part in this complex mix of relationships that was amplified by each additional layer of pavement.

First, there are those conditions inherent in the structural configuration of the roadways and the landscape they traverse, i.e. the intrinsic, fixed conditions in which they exist. Next, there are the external forces of man and nature that are continually interacting with these basic, though malleable, conditions. Last, there are the resulting interrelationships formed that constantly mutate these conditions because of the variable nature of their interactions.

Physically, the roads are defined by their alignments, surfaces and drainage courses, characteristics that were set decades before pavement was installed on their surfaces. Their paving redefined these components and altered the dynamics between

street scale, the natural contours the streets traversed and their interactions with natural and human forces. Their spatial organization, both structurally and environmentally, rendered them susceptible to problems that were further aggravated with each addition to their surfaces.

With each new layer of pavement installed, a road's height rose relative to the natural topography, increasing its thickness and its impacts on the district's fabric. These impacts can be divided into two categories: those with a direct cause and effect relationship, and those that occur indirectly, or secondarily, even while at times appearing to be the symptoms of some other ailment. For example, a clogged culvert (direct impact) alters the drainage path of water; its new path through the soil may lead to a foundation wall where the errant water could promote a variety of problems (indirect impact) with numerous interpretations. For this investigation, one last term needs to be clarified: "fabric" for this study refers not just to materials specific to buildings within the district, but also includes elements of their sites, landscape, topography and the hydrology of the district.

In sum, Waterford's paved roads have inherent design and constructed conditions that interact with external forces, which affect them and create new sets of conditions that impact, directly and indirectly, many elements of the district's fabric. How those impacts manifest themselves is at the core of this case study.

Water: The Source of Most Impacts to Fabric

The underlying element involved in most of these relationships, their interactions and resultant impacts, is water. The first title considered for this thesis was, "After The Rain."

Though lacking an academic tone, it does capture the genesis of this inquiry. What happens after the rain? Having spent the better part of the past quarter century in Waterford, investigating, analyzing, and effecting solutions to building problems often relating to water, the author wondered whether there was a common source for these problems. If so, what was it?

It has been clearly documented that Waterford roads have a direct influence on how and where water within their rights-of-way is channeled. Further, the case has been made that their drainage paths are inadequate for the task of managing run-off. So, what happens to these two atoms of hydrogen and one oxygen when their path to the Catoctin Creek is diverted by the present shortcomings of a road system that evolved nearly two hundred years ago? Where does the water go?

After reviewing a variety of building problems addressed over the years and the information gathered during this investigation, the author has concluded the evidence establishes that errant water from the roadways is the main cause of the deterioration of many elements of the district's fabric.

Direct Impacts to the District's Fabric

Though easily overlooked, before addressing the impacts from paving it should be noted that the roads experience the same degradation from natural, environmental forces. Their surfaces develop cracks and potholes, their edges heave and spall and become undermined from erosion, which is why they have been re-surfaced and their edges expanded a number of times.

Buildings Impacts

The author determined from this investigation that in Waterford, the closer a building sits to the road, the more it is likely that the building's surface and structure may suffer water damage from run-off. Water migrating from the roadway need travel only a few feet, in most cases, before finding a building.

The author's house on Second Street is a case in point. Second Street is relatively level with slight undulations in the road surface. The house sits opposite one of these low rolls in the pavement. That's barely noticeable until it rains, when run-off defines its relief (Fig. 16). During even moderate rains, water is drawn from nearly fifty feet in either direction toward its façade, where the impacts begin. The one rise concrete step to and across its front porch has areas of exfoliation. After years of repeated inundation the porch piers had settled several inches, causing the floor and roof systems to sag and hinge away from the building. The piers and floor system have been replaced and righted. Water that reaches the stone foundation penetrates its crevices and reappears in the basement, where flows of fines from the wall's interior mark the breach. Molds have sprouted from the dampness of the basement floor (Fig.17). Innocuous as the road appears, attributing these impacts to errant run-off would be difficult, had the author not observed what transpired in his residence over the past fifteen years.

At the village center, where four streets come together, Water, Second, Main and its up hill extension, the sheer height of the pavement is a visual impact in its own right, three buildings at this juncture have experienced the same impacts of water to their fabric. These masonry buildings, one on either side of Main Street and the third on

Figure 16: Uncontrolled storm water, on sidewalk, author's house. [Source; Author, 2003]

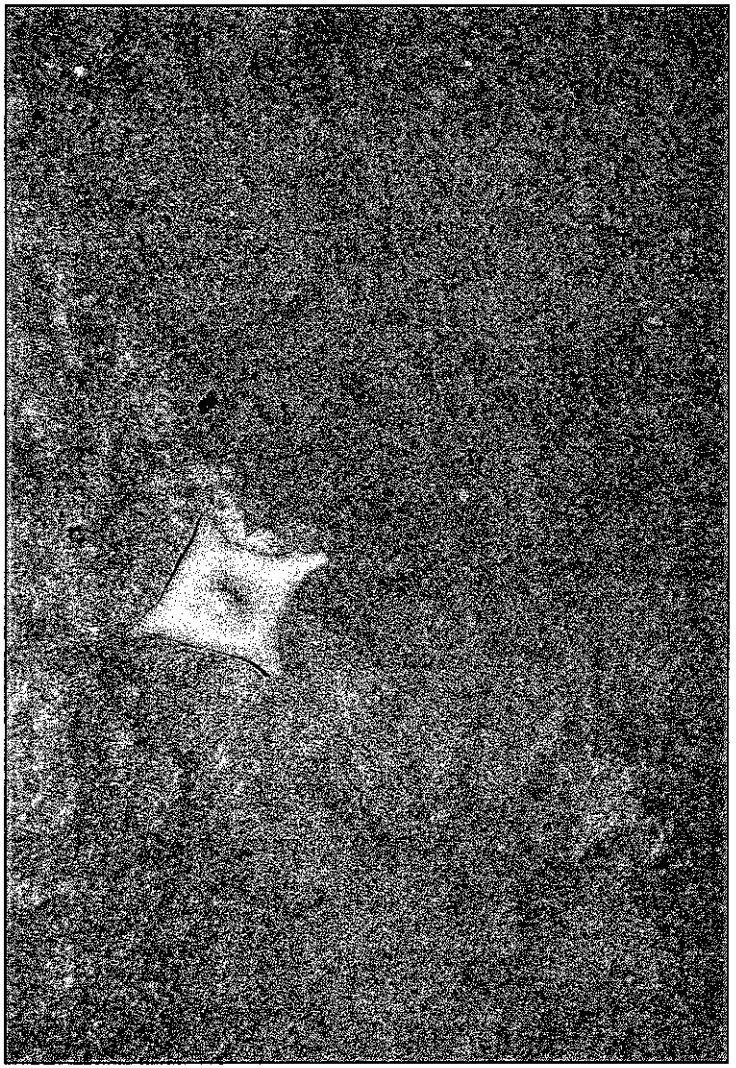


Figure 17: Mold growth, basement floor, 2" height and width, author's house. [Source; Author, 2003]

Second Street, have all had the first three feet or more of their brickwork replaced during the past eighteen years.

Looking at these cases with the knowledge that brick produced in nineteenth century Waterford tends to be soft, causing the buildings to be susceptible to numerous ailments, one might think the bricks had simply reached the end of their serviceable lives. Considering their dates of construction and when they were repaired, other than their visible defects, they would appear to have nothing in common. They all have and experience a different micro-climate, but a closer look at the details of their settings, the road edge near each building and where runoff flows, points to a common factor: storm water at their respective doorsteps.

The first building, the post office, was built in 1880 and repaired in 1986. It is located on the south side of Main Street, and is in the direct path of run-off once it crosses the intersection. Its shallow curb and five feet of brick sidewalk is its only separation from storm water. The next building, a residence opposite the post office, was built around 1820 and repaired in the early 1990s. Remnants of its once functioning curb are barely visible. The road shoulder, filled with gravel flush to the road surface, allows run-off to puddle next to its entire front facade. The third building was constructed in 1872 and repaired in 2002. Originally the headquarters of Loudoun Mutual Insurance Company, and now a private office, it has a precipitous drop from the road to its sidewalk and the entry of the building. Even with the benefit of a storm drain inlet to its immediate side, on occasion it has had water running through its door after heavy rains.

In all three cases, the wall brickwork deteriorated to the point of needing replacement because of repeated assaults from moisture. Each suffered the effects of

large quantities of water and moisture moving on and below the ground to the brickwork, then rising through capillary action that accelerated the conditions for damage to occur. Presently, the same areas of brick repaired on the Post Office façade just eighteen years ago, are showing the same symptoms of deterioration. While the specifics of these problems, the properties of their brick and the thermal and moisture characteristics of each wall may vary, the source of their deterioration mechanism – water –can be reliably traced to the road edge.

On Main Street, just up from the mill, sits a small brick cottage that has endured the ravages of migrating water for centuries. Surface run-off from six hundred feet up Main Street follows the curb to its western property line, a narrow intermittent creek bed, where it then turns and proceeds to the Catoctin Creek. In the early nineteenth century when the house was constructed Main Street crossed the creek bed via a ford, now spanned by a bridge.

Three years ago, during an extensive rehabilitation of the building, the extent of damage it received from water permeating its walls and sub-grade was documented in detail. In this case, though unknown at the time, there were two sources for the incoming water: run-off from the road and groundwater following the sanitary sewer line under the road that percolated up in the crawl space. The source of ground water can not be determined, though springs and precipitation are probable sources. However, it is also likely that run-off draining to the road edge where it is partially absorbed into the ground, increased the amount of water following the sewer line.

The potential for impacts to this building began long before the roads were paved. When the ford was replaced with a bridge, the road needed to be raised to accommodate

the bridge's elevation, immediately putting the building in jeopardy. An archeology dig across the street a few years ago determined the original roadbed was twenty-six or so inches below its present height. The original level is about right, (from a visual read of the gradient), for the road to dip down to ford the creek. In light of the building's proximity to the street and the road's increased paved height, it was only a matter of time before this structure would incur damages.

Initial inspection found the stability of the building threatened by nearly every imaginable manner of deterioration attributable to water. There was also evidence of many repairs to these symptoms. The building's brickwork had signs of repair and repointing on every elevation. A sump pump and a variety of non-functional drainage pipes in the crawl space showed the problem at least was recognized; but its solution remained elusive. There was standing water in the crawl space, droplets of water hanging on its bowed and cracked stone foundation walls, soaked insulation, mold covering most surfaces and a wood joist system with moisture contents above thirty percent on average. These conditions remained unchanged, even after long dry spells, suggesting run-off was not the only culprit; another source of moisture must have been contributing to this problem.

When the building's perimeter was excavated to determine what approach would best address the foundation settlement, cracks and bows, suspecting hydrostatic pressure and moisture penetration, the additional source of water was found. Waterford had a public sewer system installed in 1976, to replace aging individual septic systems. The sewer line for this house had become a conduit for ground water following the sanitary sewer under the road; its path to the house poured some five gallons per minute into this

already sopping environment first created when the road across its front was raised over one hundred years ago. Several photographs taken before the central sewer was installed have been helpful in distinguishing the physical impacts already occurring before being accelerated by this additional water source. They all show the same symptoms: settlement cracks in the brickwork leading to cracks in the foundation, an out of plumb chimney, out of level window sills and numerous areas of deteriorated brickwork, eroded and missing pointing, and areas of failing repairs. The photographs document that many symptoms were treated a number of times, but the source of their ailments was never fully addressed.

Treatment of the underlying source of these aliments, while not the subject of this investigation, did unveil the cause of their impacts: the installation of the sewer system into an environment that was already compromised by wayward water from the roads. Interestingly, the author's house, a quarter of a mile away had the same water intrusion problem caused by its sewer lateral until it was redirected.

On the south end of Second Street is another house that has had a plethora of problems caused by water from the road. To begin, grade falls from the road toward the house. Discharging at its front is a culvert that carries run-off from the other side of the road to the drainage ditch running in front of the house. The problem is that the water needs to then make a ninety-degree turn and pass through another culvert, less than ten feet away, that goes under a large silver maple, some sixteen feet in girth (Fig.18). Neither the culverts nor the ditch functions very well, if at all, remaining silted and clogged most of the time to the point of being barely visible. As a result, the water has been finding its way into the partially excavated basement for decades, producing

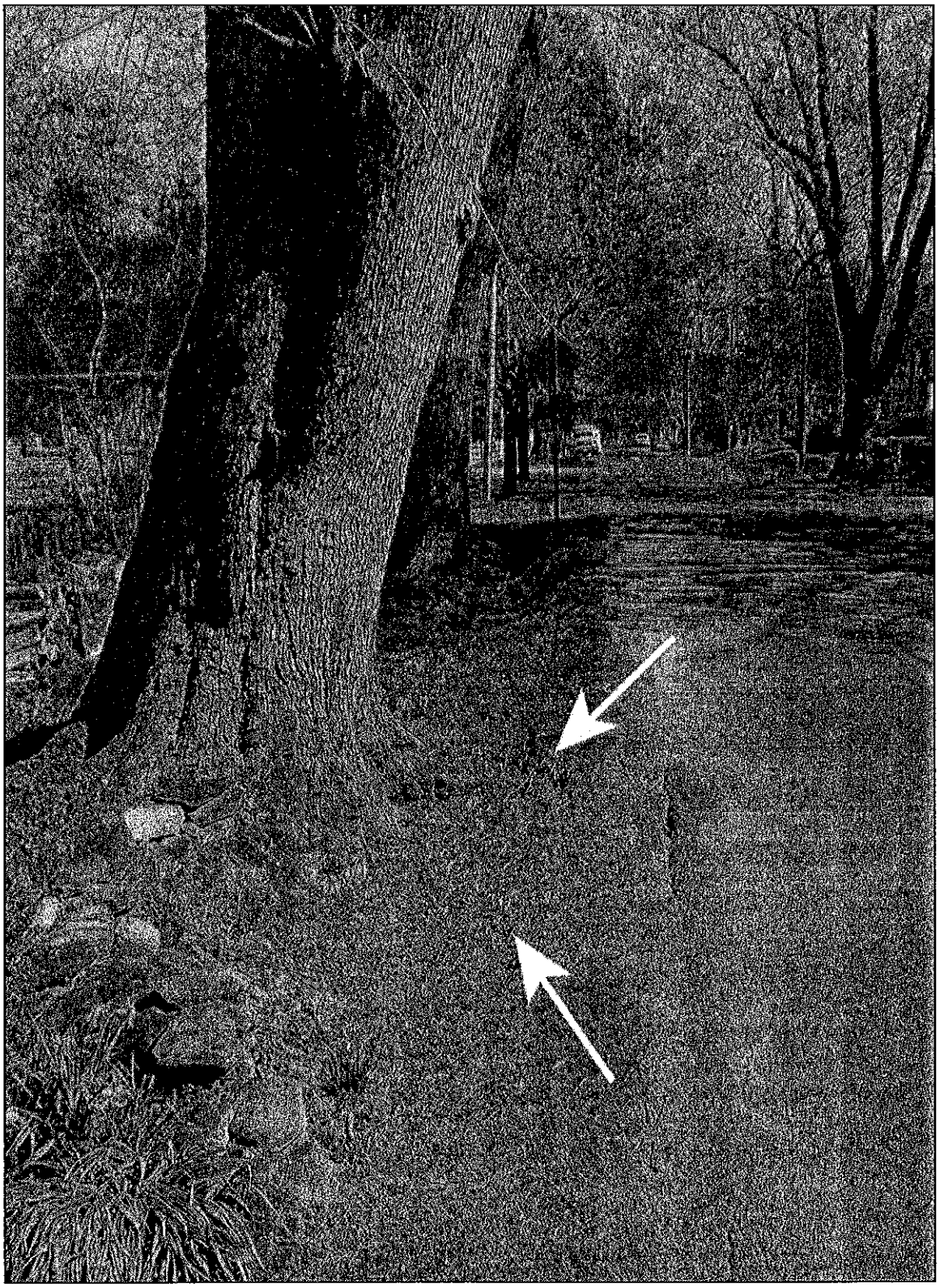


Figure 18: Clogged culverts. [Source; Author, 2003]

conditions that led to the collapse of its foundation walls and created an ideal environment for wood-destroying insects.

The author's knowledge of this building goes back twenty years, when his wife-to-be lived there. At that time, a sump pump was installed because the cellar was constantly flooding. Later residents attempted to alleviate the problem further, with drainage lines below grade, but also aggravated it with plantings, raising the grade against the house and a board sidewalk that tended to trap water. Years later, in 1992, when adding a rear addition to the house for its present owner, it was noted a few stones of its foundation had fallen in. Five years later, in the midst of a kitchen remodeling, it was discovered the entire foundation had collapsed. The final blow occurred three years later, when a termite infestation was discovered, requiring the entire joist system and portions of the flooring to be removed and replaced.

Every one of these damaging impacts was directly related to the path of water from the road, deposited across the front of the house. Unfortunately, the damage was repeated a number of times through different mechanisms before the true cause of the symptoms was recognized.

The impacts cited in each of these examples have moving water as a common factor. They were chosen because their deterioration and its source could be clearly demonstrated. There are many similar examples in the district, though the further from the road they are, the more difficult it becomes to directly link them with errant water from the roads.

Site Impacts

The word "site" is used here to refer to the land within and surrounding the historic district. A site is defined by its "topography," the lay of the land, expressed by the elevation and relief of its surface as formed over geological time and as altered by man. Its "landscape" displays the product of interactions among natural and cultural processes, the land, the flood plain, agricultural lands and land devoted to buildings and infrastructure that have come to define the district's character.

Eons before Waterford was settled, its natural topography had been defined. Once settled and its spatial structure established, it became a landscape. When its gravel pavements became the base course for its paved roads a whole new set of relationships emerged that altered that landscape. Keeping in mind that nothing exists in isolation and that most everything in nature is interconnected, the dynamics of Waterford's landscape with the natural world was bound to change and in turn modify its environment, after the roads were paved.

Specific impacts to the district's landscape are not as easily discerned because of their expansive nature, once one moves away from their visual evidence at the road edge. Where buildings more readily display damage to their structures and surfaces, the signs of damage to the landscape are more difficult to measure and define. The natural environment absorbs and disburses the forces of nature through a much larger substrate, diffusing their energy over a much larger area. Without the aid of scientific study and measurements the evidence is mostly circumstantial. However, although a case can still be made that there are effects, the question remains whether they have an impact upon the health of the landscape.

The moment water moves off the road surface, its potential for damage grows tremendously. The laws of physics govern what happens next. Depending upon the speed and quantity of water conveyed, when drainage paths are not maintained, precipitation and melting will clog and silt-up culverts, storm drains and ponds. The course of seasonal weather will continue to erode and scour the drainage paths, create divots and gullies and send gravel, bits of debris and fines downstream, further altering the drainage path and posing threats to landscape fabric. Once outside the normal drainage path run-off water causes further damage. Fast-moving, uncontained water will flatten grasses, cause sheet erosion and flood gardens and yards. Wayward water also affects soil and hydrologic characteristics. The fines it carries in suspension, when deposited on the soil, decrease its permeability, and affect absorption patterns, which then affect roadside plant and wildlife. Multiply these effects by the number of drainage paths for water moving through the district and it's clear that the balance between the built and natural environments of the landscape will be upset, if not maintained.

What is true for buildings also applies to the landscape, i.e., the further from the road water travels, the greater the difficulty in assigning direct impacts due to run-off because of the larger area of dispersion involved with its absorption. Nevertheless, it is certain the uncontrolled concentration of water passing along the road edges, down slopes and collecting along the lower streets in search of a way to the creek has caused significant physical damage to the landscape's fabric, and can lead to further, impacts to the district's natural and cultural landscape, beyond the road edge.

Indirect Impacts to the District's Fabric

The indirect impacts discussed here are associated with, but not directly attributable to, the road pavement. They can be described as being one or more steps removed from having a direct connection to their source. Think of them as secondary, or latent impacts. For example, under certain conditions passing vehicles can produce harmonic motions that rattle windows, or send vibrations through the ground that can affect building foundations. These phenomena are not unlike repetitive explosions or passing freight trains that send vibrations through the air and ground, but to a much lesser degree.

Indirect Physical Impacts

Many environmental and biological impacts come from pollution. Carried through the air and across the ground, pollutants affect many elements of the roadside environment. Though not caused by the physical road itself, they are a by-product of vehicles using the road. Contaminants such as brake and tire particulates, deicing chemicals and exhaust gases have potential impact when deposited on the road surface. Surface and ground water carry these contaminants toward wells and recharge areas, affecting ground water quality. The health of roadside vegetation is altered by the concentration of pollutants at road edges by disrupting the exchange of nutrients in the soil. Air currents carry these same pollutants, decreasing air quality, and posing obvious health risks to young and elderly inhabitants and those with respiratory problems. Noise from vehicles driving along the district's narrow streets is a constant drone that diminishes community peace and quiet, especially during commuting periods. Carbon

emissions alight on buildings, staining their surfaces with black streaks that require specialized skills to remove safely and without damaging the building surfaces in the process. Speeding vehicles endanger the safety of pedestrians, cyclists, children, pets and wildlife. Heavily laden trucks aggravate these impacts further, as they pass through the district.

The progression of these impacts has been intensified by the rapid growth and development Loudoun County has experienced over the past few decades. For the past few years it has been the fastest growing county in the state and is now the fastest growing county in the country. What was once rural, is rapidly becoming suburbanized. Large tracts of farmland are giving way to development. Less and less of the farmland surrounding the district remains agricultural. Houses have replaced crops and pastures, increasing the number of household vehicle trips per day through the village. Construction vehicles, commuters and pass-through traffic from other areas have compounded the impact from vehicles negotiating the district's roads. All of this dramatic growth in employment, households and population brings with it increased traffic and pollution that have accelerated the impacts visited upon the district's fabric.

Indirect Perceptual Impacts

Road paving has also affected the visual perception and interpretation of the district's historic landscape and character. The roadways, their alignments, surfaces and edges all contribute to the physical qualities that define the district's character. The roads' raised elevations, their eroded edges and piecemeal attempts to correct drainage problems with inappropriate materials have diminished the integrity of these critical edges. Curbs

and gutters that once channeled run-off have deteriorated, collapsed and heaved from water infiltration. In some places, pavement placed in drainage ditches nearly covers the curbs. More egregious impacts to the district character have been caused by the use of pavement to create rolled curbs that bury the old curb and gutter and rest on the brick sidewalk. Successive layers of paving have had the unintended, but discernable, effect of degrading the character and feeling that defines the district's integrity, demeaning the district's landscape.

Waterford was designated a National Historic Landmark District because of its extant, nationally significant historic buildings and landscape that exemplified the patterns of development of a pre-industrial rural village, indicative of our nation's cultural evolution from the 18th through the 20th century. Since being designated a national historic landmark in 1970, its roads have been resurfaced often. The Landmark has been changed and impacted by the present condition of its roads. Their deteriorated drainage paths combined with the super elevation of their surfaces have induced damaging effects from uncontrolled water to the physical properties and quality of its buildings and landscape. Recognition of this fact was impetus for this thesis.

The extensions of these impacts have real costs to property, the health and safety of residents and the district's environment, landscape and integrity. Quantifying these costs and assigning attribution directly or indirectly to the paving of the district's roads would be troublesome, due to the number of variables that need to be considered. In this analysis, quantification is unnecessary. The important thing is that it has been documented that damages have occurred, from paving adversely affecting the physical functions of the district's drainage out flows whose paths are pot-marked by the erosions

of water outside their courseways. Further defining these impacts to the district's fabric on a perceptual basis is subjective. That is to say, we only see what fits our frame of reference and knowledge; everything else either does not register, or has achieved such commonality or acceptance that we no longer recognize it as an impact. Once this point is reached it takes a reawakening in the art of seeing to understand and appreciate the impact these threats pose to interpreting the district's integrity and character from further damage.

Waterford's remoteness in the backwaters of Northern Virginia had allowed it to escape the influences of development for a long time and permitted its historical character to remain intact. The improved accessibility and mobility afforded when its roads were paved are partly responsible for its resurrection. Its first course of paving was laid over roadbeds defined one hundred years earlier. Since then many more layers have been added to their surfaces. Road improvements in towns and cities maintain a set elevation because of fixed drainage infrastructure, but Waterford's road elevations have grown higher and partially buried the fixed drainage infrastructure. Instead of treating the district's road improvements and upgrades as part of an infrastructure system with defined drainage paths, improvements have consisted of repeated layers of paving, with little concern about their drainage, except to feather the pavement edges to grade. Such an approach may be appropriate for a country road, but is inappropriate in a village with defined benchmarks. The results of this method to improve the district roads have adversely impacted the defining qualities of its physical and perceived environment.

The origins of these impacts are found in a tangle of interrelationships that began with the well-intended act of delivering a rural community mired in the mud for centuries

into the mainstream of the twentieth century. The missing element to these paving improvements was an analytical road design and management plan that integrated the natural and human elements of the district. A road management program that emphasized maintenance of the drainage system would have extended the life of the road surface and lessened the layers of paving now adversely affecting the district's environment and integrity. Maintenance is synonymous with preservation; proper and timely maintenance is the most cost-effective means to preclude more costly, disruptive wholesale repairs. Instead of a systematic evaluation of drainage systems and prioritizing their maintenance on a regular basis, considering budget limitations, deferred maintenance has become standard operating procedure. Yet, what would be the most fruitful way to maintain the rural roads of Virginia is the most overlooked aspect of roadway management.

CHAPTER V
SUMMARY, RECOMMENDATIONS, FURTHER RESEARCH AND CONCLUSION

Transportation systems have played a dominant role in supporting the economic and social development of our society from the time of its earliest settlement to the present. The first settlers built and maintained those systems of transportation within their communities to pursue their livelihoods. As the country developed and our population grew, road systems evolved beyond local commerce and transportation into a network of interconnected roadways that have spanned the continent. In the process of achieving these connections, our landscape, the natural environment and our culture have been reordered. Our road system is now the largest public infrastructure system in the world, so large in fact, the Interstate Highway System can be seen from orbiting spacecraft.[78]

The evolution of our road systems encompasses a vast area of study, and the tangible and intangible changes to our world from that evolution are enormous. This investigation has tried to unfurl one small part of this transformation: how the evolution of road paving in rural historic districts has impacted their integrity. Rural roads evolved gradually in relatively isolated locations where roads were adapted and improved to accommodate the particular needs of the local people who used them. In contrast, roads within and around urban regions needed to be structured and ordered early on, imposing unity upon the landscape for the efficient movement of commerce, the administration of

government and for necessary infrastructure, thus creating a completely different type of road system than those of rural areas.

For centuries, the roads of rural Virginia had been controlled, administered and financed by individual counties. Before the advent of motor vehicles, they were built to accommodate the needs of horse and wagon. Little had changed along the roadscape for centuries. During the first decade of the twentieth century, however, the burgeoning automobile and truck industry reshuffled the needs of our country's transportation infrastructure. But two essential elements for road construction and maintenance were missing at the time: money and engineering expertise.

Funding for new and improved roads has a long history of being shy of what's needed, a dilemma that continues to this day. As noted in Chapter III, Virginia established its first Highway Commission in 1906 to assist counties by providing engineering and technical advice for road improvements, though little came of it due to the absence of adequate construction funds. The search for funds sufficient to keep up with the need for new and improved roads created by the public's adoption of motor vehicles was ceaseless. In 1909, the state provided some improvement funds, but they had to be matched by the counties. Additional funds were raised through licensing and registration fees, but road needs continued to escalate. The federal government "first supported building a national system of roads with passage of the Federal Road Aid Act of 1916. The great growth in automobile registrations and the demonstration of the value of long-distance trucking during World War I led to passage of the Federal Highway Act of 1921, which provided aid for states to build a connected interstate highway system through fifty-fifty matching grants."[79] To receive federal matching funds states needed to

establish a state highway system and devote their resources toward connecting the main roads between their population centers into a state road network. Virginia established its state highway system in 1918, removing over four thousand miles of roads from the responsibility of the counties. While states and the federal government were focused on developing state and national road systems, little was done to improve the roads where most of the populace lived and worked. The need and demand from the motoring public was continual.

The solution formulated for road funding was to tax the road users. In 1923, the Virginia legislature adopted a three-cent per gallon levy on gasoline. A gas tax proportionally charged those people who used the roads for their construction and improvement. The gas tax successfully raised millions of dollars for road construction. By 1932 all the states and the federal government had instituted a tax on gasoline. Driven by the ever-increasing number of vehicle owners, the tax became the main source of revenue for road building and improvement projects. However, these funds remained earmarked for only those roads within the state highway system, even though the majority of the populace, while paying the tax, worked and resided in rural regions where little improvement to the roads occurred. Rural roads were still being funded by county property taxes.

In 1932, after years of acrimonious complaints from rural residents could no longer be ignored, the state legislature passed the Byrd Road Act, relieving counties of their road management responsibilities. Rural roads became the "secondary road system," and counties relinquished responsibility for improvements and maintenance to the state department of highways. The state road system became the "primary road system."

Finally, improvements were foreseeable, though it would be decades before most roads were improved with pavement or all-weather surfaces. The actual methods employed for their improvement differ in numerous ways, as explained in the case study, from those used for large towns, cities and primary roads.

The engineering expertise sorely needed for the improvement and construction of roads capable of withstanding the weight and passage of trucks and automobiles on a continual basis did not exist when motor vehicles first appeared. The difficulties incurred transporting military supplies and equipment during World War I had made this inadequacy obvious. An entirely new industry emerged to fulfill this need, focused on developing the techniques, materials and construction standards sufficient for motor transport. Their energies were directed toward development of a connected interstate road system. At the county level of government during this period, road management was quite different. There were few, if any, engineers or road building equipment available for rural road improvements. Today, these shortages appear to have been a fortuitous occurrence for the preservation of rural roads, especially those of rural historic districts.

As documented in the case study of Waterford, many unintended consequences have occurred because there was not a road design or management plan from the outset. But consider the possible alternatives if there were. The road building industry and VDOT historically have resisted anything other than standard textbook solutions to construction, mainly a one-size-fits-all approach that can turn rural roads into rural speedways. While more sensitive and flexible methods are available, their single-minded approach has remained entrenched. In Waterford, implementation of this method would

have more than likely removed, altered and transformed the village's road characteristics to the extent that the context of the village's history would have been lost.

The circumstances during the Depression when, Waterford received its first layer of paving, i. e., limited funds and little or no engineering expertise, were unwitting accomplices in the preservation of Waterford as a significant example of a pre-industrial rural village. Though the impacts from that first layer are negligible in comparison to the public benefit, the aggregate of successive pavement layers, combined with sporadic maintenance of the drainage system has had many damaging consequences. The present road height and condition of the drainage system precludes repaving without first removing a considerable amount of the previous layers and rebuilding the entire drainage system. Anything short of lowering the roads and repairing their drainage capabilities will only accelerate the impacts incurred by buildings and the district's landscape, and continue to degrade the visual quality and contextual interpretation of the landmark.

Recommendations

While researching the review requirements of various transportation legislation the author discovered the absence of any requirement for review or assessments after projects are completed. All review requirements concern pre-construction analysis of potential environmental and cultural impacts arising from transportation projects and means to avoid or lessen perceived adverse impacts, but there is no provision for post-construction reviews to ascertain how successful they actually were at achieving those goals. Without follow-up assessments there is no assurance that impacts similar to those that have occurred in our rural historic districts are not also occurring on a much larger

scale to our natural and cultural environments. This legislative omission should be remedied.

What is needed to rescue the roads of historic districts like Waterford from further degradation are standards for recovering and retaining a healthy roadway environment that enhances, rather than diminishes, a district's integrity. The tolerable limit for pavement elevation already has been exceeded in Waterford, and similar conditions exist in other historic districts in Loudoun County. Bluemont, Goose Creek and Taylorstown historic districts all show signs of detrimental erosion impacts from poorly maintained drainage paths and elevated road grades. Accordingly, instead of milling off an inch or two, then adding back an equal or greater amount, which only maintains the status quo, a new approach is in order.

The most important component of these maintenance and management standards, formulated to eliminate the impacts caused by uncontrolled water and waterborne pollutants from the roadway is, a comprehensive drainage management program. The necessary steps in this program are to:

1. develop a regularly scheduled visual inventory of drainage system and surface conditions to determine how well they are functioning;
2. evaluate these conditions on a scale from poor to excellent;
3. prioritize the maintenance schedule and repairs based on these evaluations; and
4. conduct follow up assessments of maintenance and repair work to determine if they were adequate.

Otherwise, even a road with all the proper drainage elements will deteriorate if its maintenance is neglected. Bi-annually scheduled follow-up assessments to determine how the system functioned as measured by the envisioned goals are essential. Such a plan will produce immediate and long-term benefits for preserving the integrity of rural historic districts.

For long-term solutions it is recommended that:

1. pavements that have attained a height such that their elevation is directly or indirectly responsible for degradation of the property of abutters along their rights-of way must be returned to an elevation that allows resurfacing for the next fifty years before having to repeat this same process; and
2. drainage systems must be redesigned to be compatible with each surface improvement, and a drainage system maintenance program must be implemented that bi-annually assesses and prioritizes its condition and then follows up with a maintenance schedule addressing any deficiencies impairing its functional integrity.

Additionally, there are guidelines and standards published by various government and highway agencies that support context-sensitive approaches for road improvements that can be massaged,[80,81] then incorporated into standards for the reclamation and retention of historic district roadways. Roads and the relationships they have with buildings and the landscape are an integral part of any historic district's character. Therefore, road maintenance and improvement needs should be defined by the context of these relationships. They must relate the physical components of each road recovery project to the conditions specific to the district and its history. They must be developed

and designed within a framework that supports and validates the perception and understanding of the district's evolution and its road system.

If implemented, such a comprehensive program will produce an immediate base of knowledge for drainage management that can then be used for analyzing and refining the most appropriate methods for long-term drainage management, lessening detrimental impacts and extending the life span of the road system of historic districts. At the same time, incorporating the suggested guidelines for long term reclamation repairs to rural historic district roads into transportation improvement policy will insure protection of the contextual elements that define their significance, and insure the continued preservation of the district's integrity. The roads of Virginia's rural historic districts can no longer simply be repaved without eviscerating the qualities and characteristics that provide us with a tangible connection to our past.

Further Research

Based on research findings and visual investigations, the author has made assumptions in this thesis that would benefit from further research. It has been implied that the roads of rural historic districts in Loudoun County are typical of how all the state's rural historic district roads have evolved. Site visits to rural historic districts in other regions of the state are needed to confirm this premise.

A clearer understanding of the roadside ecology would be acquired from a variety of in-depth scientific studies associated with the environmental impacts of storm water run-off. Such studies would measure the level and extent to which pollutants have changed the microclimate of roadside plant and animal life, altered soil conditions and

the quality of ground water, and affected the supporting environments of aquatic plants and animals.

The built environment can be utilized as a barometer for measuring the adequacy of future drainage improvements. During the course of conducting a water circumvention project, the author installed a number of deep wall moisture probes in a foundation, aligned vertically. Readings were taken every day over a three-month period; after every rain there was a noticeable rise in the readings. A similar procedure could be used in suspected trouble areas. By monitoring the moisture content of building foundations close to the road, the effectiveness of road maintenance and improvement projects would disclose where the water goes.

Conclusion

The case study findings have documented impacts which, though not apparent from casual observation, cannot be ignored if the National Historic Landmark of Waterford, Virginia is to retain its defining qualities. Roads within the district can no longer tolerate the shortsighted policies of a highway department that addresses road maintenance and repair in a piecemeal manner. The absence of a road drainage maintenance and management plan has led by default to repeated layers of paving, which have produced adverse consequences to the district's fabric and integrity.

Buildings adjacent to the roads have experienced deterioration to the component materials that make up their structures, in some cases resulting in system and/or structural failures to foundations, walls and floor systems from uncontrolled water entering their

envelope. These failures required homeowners to make extensive and expensive repairs that could have been avoided with proper maintenance of the road drainage system.

Concurrently, the same wayward water has eroded and abraded the natural fabric of the district's landscape, changing the natural outfalls for run-off to Catoctin Creek, and carrying debris, gravel, soil particles, and pollutants beyond the road edges to damaging effects. The uncontrolled water has altered soil characteristics, and in turn damaged plant and animal habitats, silted ponds, caused unwanted changes to aquatic plant and animal environments and deposited pollutants in ground water recharge areas. The health and stability of these components of the natural landscape are continually threatened by the inadequacy of the district's road drainage system.

The visual perception and interpretation of the district's historic character has also been impaired and diminished by its heightened road grades and deteriorated road edges. These relationships between the streetscape, landscape and buildings that define the district's heritage are in jeopardy of being further eroded if nothing is done to change how the district's roads are managed.

It is time to raise the awareness and recognition of all who are affected by these conditions, to gather abutters, community organizations, county administrators and highway officials in a cooperative effort to implement the recommendations of this study. The recommended comprehensive maintenance and management program is a feasible way to protect and preserve the historic and cultural resources embodied in rural historic districts like Waterford from being adversely impacted from misguided paving improvements. Only if such a program is implemented will we know with confidence where the water goes after the rain.

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