Town of Norwich

Transportation Capital Program

2007 - 2015

Rubberized Pavement on New Boston Road

December 2006

Acknowledgements

This report was prepared by

Robert Merchant PE, MARCON Corporation
Island Pond, VT

in collaboration with

Chuck Wise, Transportation Planner, TRORC

and the support of

Andy Hodgdon, *Norwich* Road Foreman

The 2006 road inventory was done by

Robert Turner, RJ Turner Company

The maps were prepared by

Chuck Wise, Transportation Planner, TRORC

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Town of Norwich.

Executive Summary

A capital program demonstrates knowledge of the infrastructure and what investment is appropriate to maintain that infrastructure in an acceptable condition. The investment should be in terms of when, what for, and at what cost; the essential components of a Capital Program.

Roadway maintenance is focused on continuance of a serviceable condition on all of the major elements in the roadway. These commonly include the surface, guard rail, drainage, and signs. Roadway maintenance, in the context of cost for a capital program, ***does not*** include winter activity, mowing, pothole patching, culvert cleaning, etc which are not considered to improve the roadway for any significant length of time.

In this study, we focus on paving in the Town of Norwich as a system maintenance activity; one that is a significant element in the annual budget.

Norwich has invested modestly in the past for its paving activity, and in the most recent years at the rate of around $200,000 per year.

Deciding what amount to budget in the next decade and where to invest that amount, required a substantial analysis effort. To do this work we used a sophisticated software titled dTIMS. The analysis suggests an increase is needed in the annual budget to continue the trend toward few Very Poor miles. Also, it suggests that an emphasis on less costly treatments applied earlier (and at a more frequent pace) is a more efficient use of the annual amount to be invested.

Assuming a continued investment in paving of $240,000 plus inflation annually, the analysis provided a listing of projects in each year through 2015. Most definitely, the listed projects need to be adjusted each year based on cost experience and actual performance of the roadways. The 2007-2009 years in this report have been adjusted to a current view.

To provide some perspective on spending necessary to improve the overall pavement condition and move toward elimination of Very Poor miles, some information relating spending to condition at the end of 10-years is included.

Presuming it to be prudent to replace a culvert in Poor condition, a culvert replacement program is provided.

Bridges present modest liability for the town due to an aggressive maintenance effort.

Contents

Topic	Page
Introduction	5
Pavement Condition Overview	6
System Improvement Program	11
Pavement Management	12
Paving Program Development	12
Routine Maintenance	20
Early Intervention	22
Alternative Techniques	25
Budgeting for Paving	26
Gravel Roads Resurfacing	30
Bridges and Culverts	33
Recommendations	37
Capital Program	38

Photos, Charts and Figures

Subject	Page
Rubberized Seal Project	Cover
Example Poor surface	7
Paved System Profile in 2006	8
Map Road Classification - Traffic Volume	9
Map Road Conditions	10
Pavement Deterioration Curve	13
Example Composite Performance Curve	13
Treatment and Condition Relationship	14
Performance with Reclaimed Pavement	16
Performance with Overlay	18
Performance with Seal	18
Forecast condition $180,000 annual	26
Forecast condition $240,000 annual	27
Forecast condition $350,000 annual	28
Forecast condition $400,000 annual	28
Map Culvert Locations - Condition	32
Bragg Hill Road Culvert	34
Bridge 39 Beaver Meadow Road - Sidewalk	35
Bridge 39 Beaver Meadow Road -Underside	36

Introduction

The question of how much spending to request on roadway surface and structures maintenance and where to effectively use those funds that are approved are two questions that every local government faces, usually on an annual basis.

Having a Capital Program is important today given the requirements of GASB-34 and the expectations of voters that there be careful planning for on-going budget costs.

To understand the overall system, a complete highway system inventory was done in August 2006 using RSMS condition standards.

Norwich has until recently been spending $90,000 each year on the 33.6 miles of paved roadways. In the 2006 budget year the amount was $205,000.

To help with planning for the future, the TRORC contracted with MARCON Corporation to make a forecast of roadway conditions at various spending levels. Once the future level was decided, MARCON would provide a paving program (list of projects) for each year in a forecast time frame.

Related to pavement management, we recommend a strategy to replace all culverts that were rated in Poor condition within a project area, one year in advance of doing surface work. Cost of this work should be included as a related cost to the paving program, as is line striping (if off the Class 2 system) and guard rail replacement.

To handle the substantial amount of analysis needed to forecast conditions and select treatments and projects, MARCON elected to use dTIMS software from Deighton Associates LTD. The dTIMS analysis depends on forecast models that predict how each of the roadway characteristics, i.e., *alligator cracking*, *longitudinal-transverse cracking*, *edge cracking , and rutting* behave over time.

The first round of analysis and forecasting found that $240,000 if allocated annually was sufficient to maintain current conditions over time. Considerably in excess of this amount is needed to improve the conditions to the extent of having no miles in Very Poor condition..

Pavement Condition Overview

- System Status and Trends

The system condition survey made in 2006 provided a understanding of current status.

2006 Survey using RSMS standards was done by Two Rivers-Ottauquechee Regional Commission

Paved segments = 67
Miles = 33.6 of Class 2 and Class 3
6.7 miles below PCI of 55

RSMS is an acronym for Road Surface Management System. The RSMS provides a good inventory definition and is a useful base for system planning.

PCI is an acronym for Pavement Condition Index, computed by the RSMS system, which uses a scale of 0 to 100, so that a roadway with no defects warrants a PCI of 100. A PCI of 55 indicates a segment clearly in need of work.

Segment is a length of roadway that is generally uniform in character. In general, the pavement is of the same type and age, and width of pavement is constant. Shorter streets will be one segment, while long roadways may have 8 to 10 segments within their overall length. *We subdivided longer segments so that our analysis worked on 111 segments.*

Reference the map at page 9 which depicts the classification of the roads in Norwich into state, town/state, town, and private categories with an indication of traffic volumes on the primary routes; and the map at page 10 which depicts the condition of the roadways.

RSMS rating involves reviewing each segment and giving a characteristic score for the total segment; a visual but still objective rating based on standard criteria for each of the segment characteristics (alligator cracking, longitudinal-transverse cracking, edge cracking, roughness, patching, drainage). The RSMS scores are awkward because they are inverted (with poor conditions having a higher score) and not all having the same base. Some characteristics have a high value of 3 and others, a high value of 12 for the poorest condition.

We find that visualizing roadway condition is made easier by converting the RSMS scores into index values of 0 to 100 with the best condition represented by 100, and categorizing the segments into the following ratings:

Excellent – new condition, no maintenance required – index value 100 to 81
Good – minimal deterioration, minor maintenance (crack filling) needed – index value 80 to 61
Fair – cracks are evident, some roughness – index value 60 to 41
Poor – cracks are prevalent and wide, some pot holes, roughness noticeable – index value 40 to 21

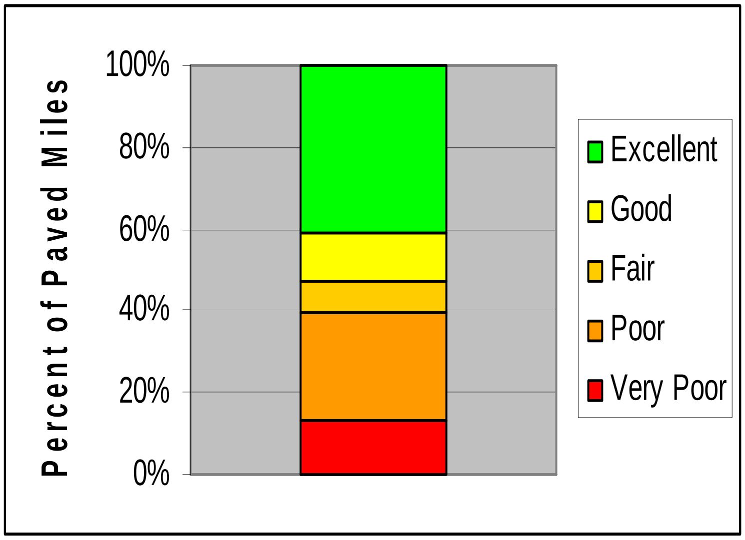
Very Poor - cracks are very prevalent and wide, pot holes, breakup on edges, may be very rough ride – index value 20 to 0

To give the reader some perspective, the roadway shown in the following photo of a segment of Rte 132 with severe ***longitudinal cracking*** was rated to be in <u>Poor</u> condition in the 2006 survey.

Rte 132 surface conditions

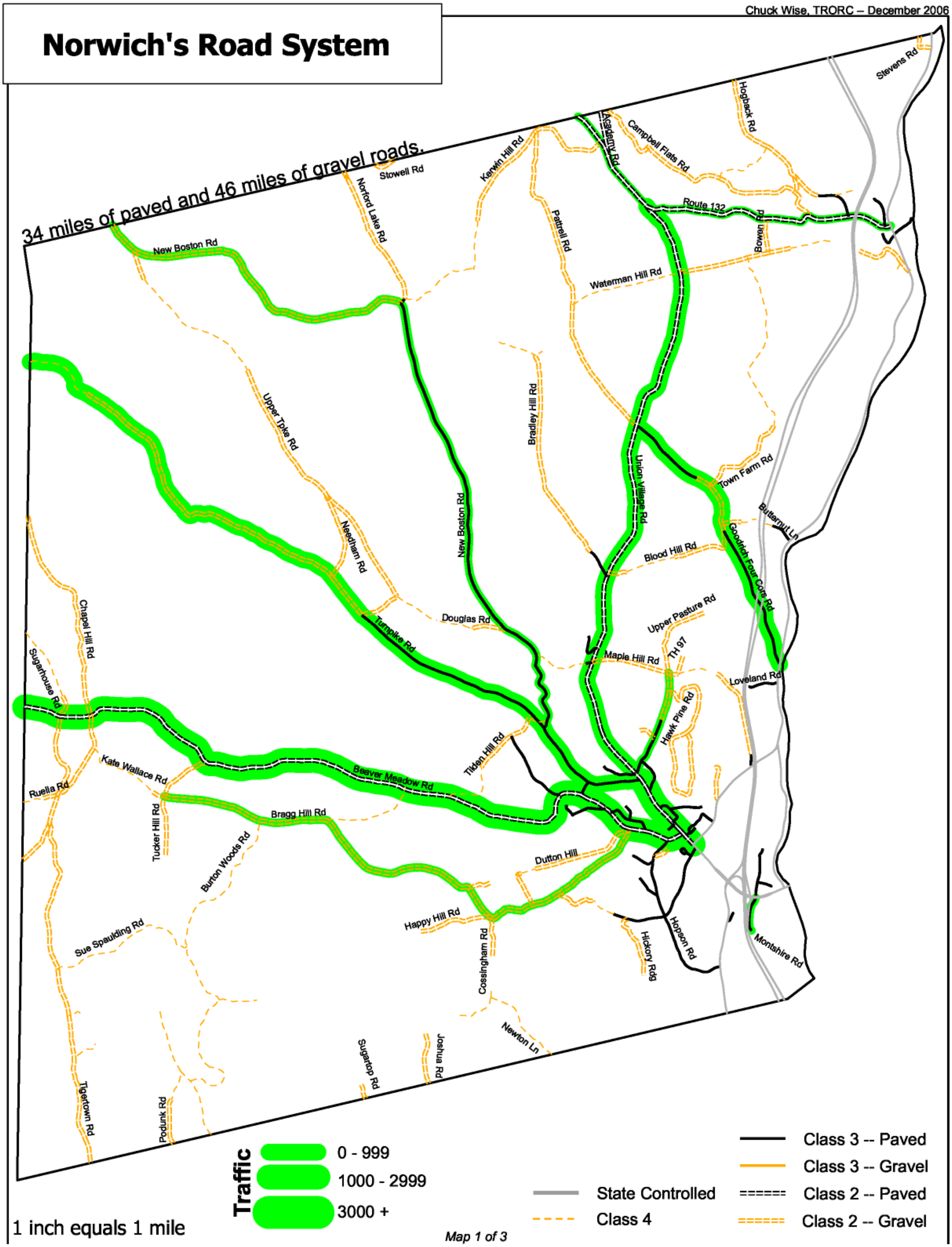
As of 2006, Norwich highways had 12.5 miles in similar conditions.

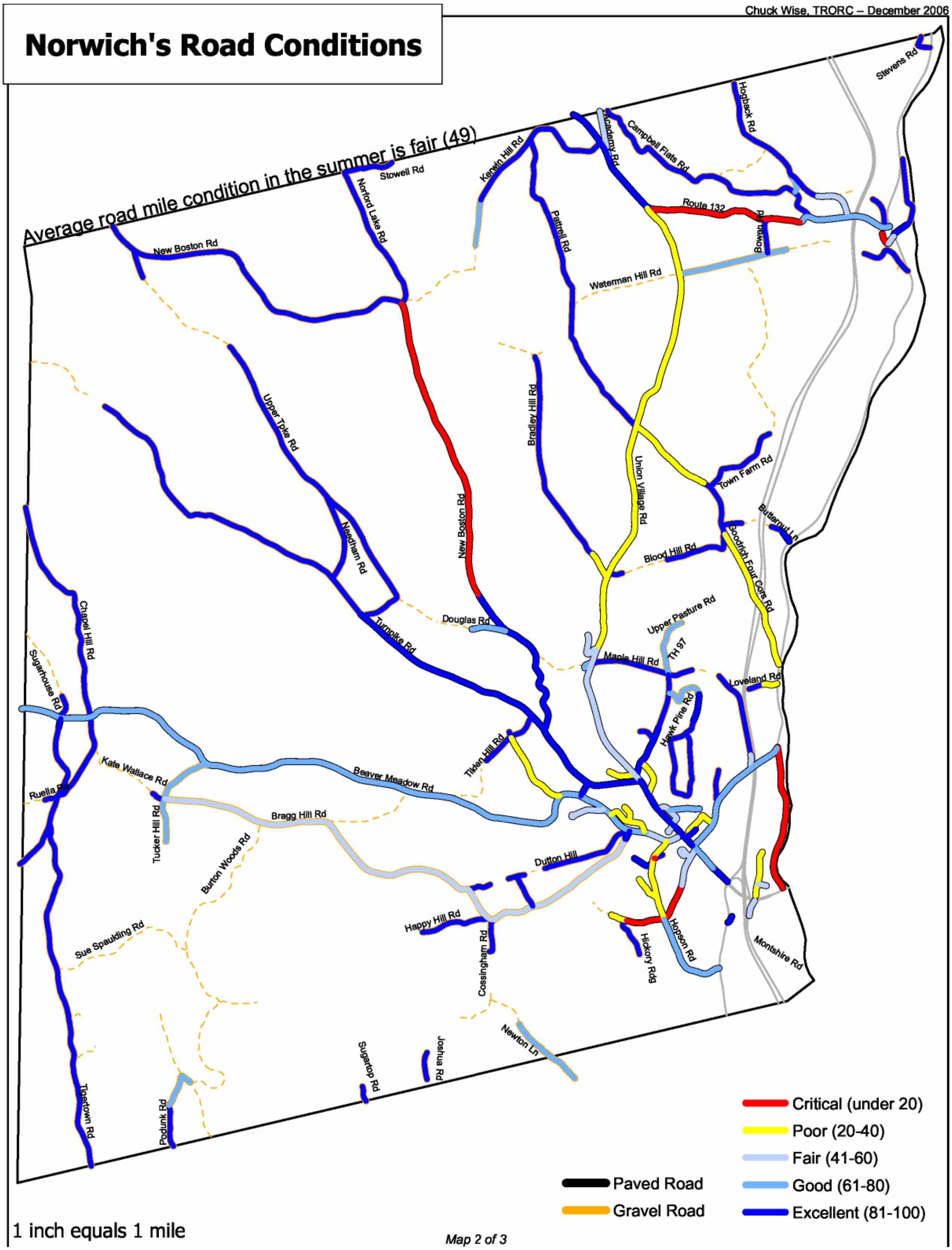
Using the RSMS inventory data we converted the segment numeric ratings into the general descriptive categories. Totaling the miles in each category, yields the following chart indicating the system profile in 2006



System Condition Profile

Reference the maps on the following pages which depict the classification for state aid purposes and traffic volumes on selected highways, and the surface condition of the streets and highways in Norwich as of 2006.


Norwich's Road System
Chuck Wise, TRORC -- December 2006
34 miles of paved and 46 miles of gravel roads.
Stevens Rd
Hogback Rd
Campbell Flats Rd
Academy Rd
Kerwin Hill Rd
Stowell Rd
Norford Lake Rd
Route 132
Bowen Rd
Pattrell Rd
Waterman Hill Rd
New Boston Rd
Upper Tpke Rd
Bradley Hill Rd
Union Village Rd
Town Farm Rd
Butternut Ln
Needham Rd
New Boston Rd
Goodrich Four Cors Rd
Blood Hill Rd
Chapel Hill Rd
Douglas Rd
Turnpike Rd
Upper Pasture Rd
TH 97
Maple Hill Rd
Loveland Rd
Sugarhouse Rd
Hawk Pine Rd
Tilden Hill Rd
Kate Wallace Rd
Beaver Meadow Rd
Ruella Rd
Tucker Hill Rd
Bragg Hill Rd
Dutton Hill
Burton Woods Rd
Happy Hill Rd
Hopson Rd
Sue Spaulding Rd
Cossingham Rd
Hickory Rdg
Montshire Rd
Newton Ln
Joshua Rd
Sugartop Rd
Tigertown Rd
Podunk Rd
Traffic
0 - 999
1000 - 2999
3000 +
State Controlled
Class 4
Class 3 -- Paved
Class 3 -- Gravel
Class 2 -- Paved
Class 2 -- Gravel
1 inch equals 1 mile
Map 1 of 3


Norwich's Road Conditions
Chuck Wise, TRORC – December 2006
Average road mile condition in the summer is fair (49)
Stevens Rd
Hogback Rd
Academy Rd
Campbell Flats Rd
Route 132
Bowen Rd
Kerwin Hill Rd
Stowell Rd
Norford Lake Rd
Pattrell Rd
Waterman Hill Rd
New Boston Rd
Upper Tpke Rd
Bradley Hill Rd
Union Village Rd
Town Farm Rd
Butternut Ln
Needham Rd
Goodrich Four Cors Rd
Blood Hill Rd
Chapel Hill Rd
Turnpike Rd
Douglas Rd
Upper Pasture Rd
TH 97
Maple Hill Rd
Loveland Rd
Sugarhouse Rd
Hawk Pine Rd
Tilden Hill Rd
Kate Wallace Rd
Beaver Meadow Rd
Ruella Rd
Tucker Hill Rd
Bragg Hill Rd
Burton Woods Rd
Dutton Hill
Happy Hill Rd
Hopson Rd
Hickory Rdg
Montshire Rd
Sue Spaulding Rd
Cossingham Rd
Newton Ln
Sugartop Rd
Joshua Rd
Podunk Rd
Tigertown Rd
Critical (under 20)
Poor (20-40)
Fair (41-60)
Good (61-80)
Excellent (81-100)
Paved Road
Gravel Road
1 inch equals 1 mile
Map 2 of 3

System Improvement Program

We are advised by town officials that for several years in the past that the town had budgeted $90,000 annually for paving, and this was increased to $205,000 in 2006.

As a rule of thumb, resurfacing should be planned at 10-year intervals. At today's prices the cost of a mile of a 2-inch overlay resurfacing is $120,000, or $12,000 per mile per year. Considering Norwich's 33 paved miles a reasonable annual paving budget would be $400,000. This amount is a considerable increase, so we will examine how this might be managed.

Highlights of Norwich's highway management practices and approach

- **Paving Practices**

Practices utilized in the years 2002 - 2006 include:

1. Crack filling has been applied routinely to all roads other than those with very wide cracks (Poor and Very Poor).
2. Shim and thin overlay (Seal) was used on 2.9 miles.
3. Structural overlay with 2-inch Hot Mix Asphalt (HMA), with shim to restore cross-section, was applied to 7.9 miles.
4. Reclaim existing pavement by grinding, and a 3-inch HMA wearing surface, was used on 2.0 miles.

The result of reclaim construction is strong roadbeds, allowing us to consider relatively long life spans for any subsequent treatment over these newly treated roads.

We are impressed that the town has already adopted a strategy of applying a seal surface rather than routinely placing an overlay.

The amount and quality of crack filling is commendable.

Conclusion

Norwich's paved highway system can generally be rated as Fair, with an overall condition index of 56 as of 2006, but of greater concern we note that over 30% of the system needs work beyond ordinary overlay resurfacing.

Assuming continued $190,000 paving budgets, the same as 2006, and addressing the worst situations at the average rate of 1.5 miles per year, it will be 13 years before the 13 miles treated since 2002 again receive attention. A 15-year service life is not likely on most of Norwich's roadways. Therefore, some effort needs to be made to extend their life, short of making large investments. The following section discusses how this might be managed.

Pavement Management Program

Typical Scenario

A typical Pavement Management Program, assuming there are no subgrade failures and subbase is adequate for wheel loads, would look like this:

Year 0	New surfacing
Year 3	Fill Cracks
Year 8	Seal
Year 11	Fill Cracks
Year 18	Shim and Overlay
Year 21	Fill Cracks
Year 27	Seal or Reclaim depending on deformation

Only the most robust of roadways will withstand traffic and weather in Vermont and perform better than outlined above. These would have perhaps four feet of frost free subgrade materials and two feet of high quality subbase such as crushed stone under the pavement; definitely a better cross-section than found on Norwich's roadways.

Program Development

The goal of a paving program is minimum long term cost and general acceptance by users that the surfaces are safe and comfortable.

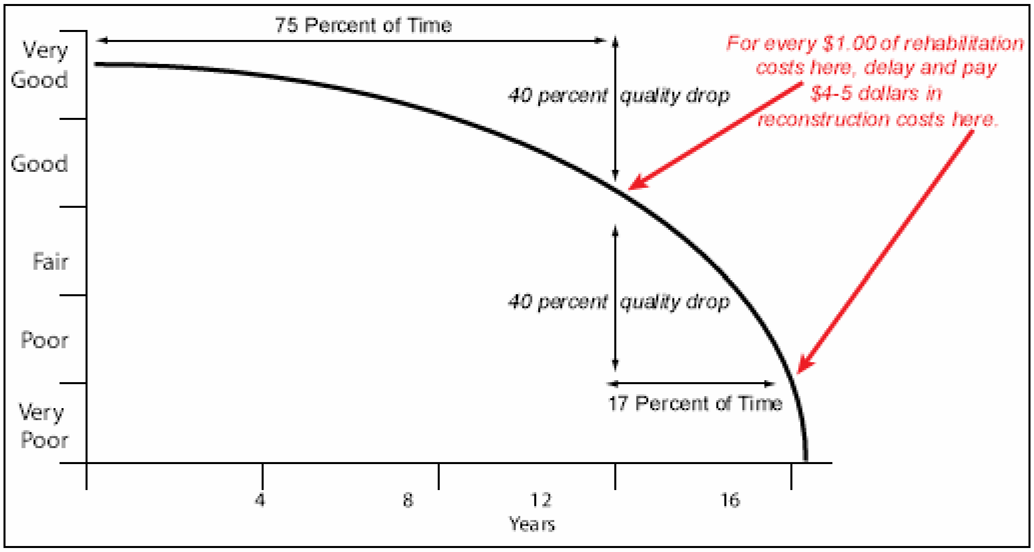
In developing a paving program (a yearly forecasted schedule of projects) our project selection is based on balancing the following two factors:

1. Funds anticipated to be available
2. Pavement condition system-wide

Selecting projects for the program began with an analysis of all the segments in the highway system by use of a sophisticated highway system analysis program from Deighton Associates LTD known as dTIMS.

- **System Analysis**

Our system analysis and program development is built around the concept that roadway pavements deteriorate in a generally predictable manner as indicated by the heavy curved line in the diagram below.

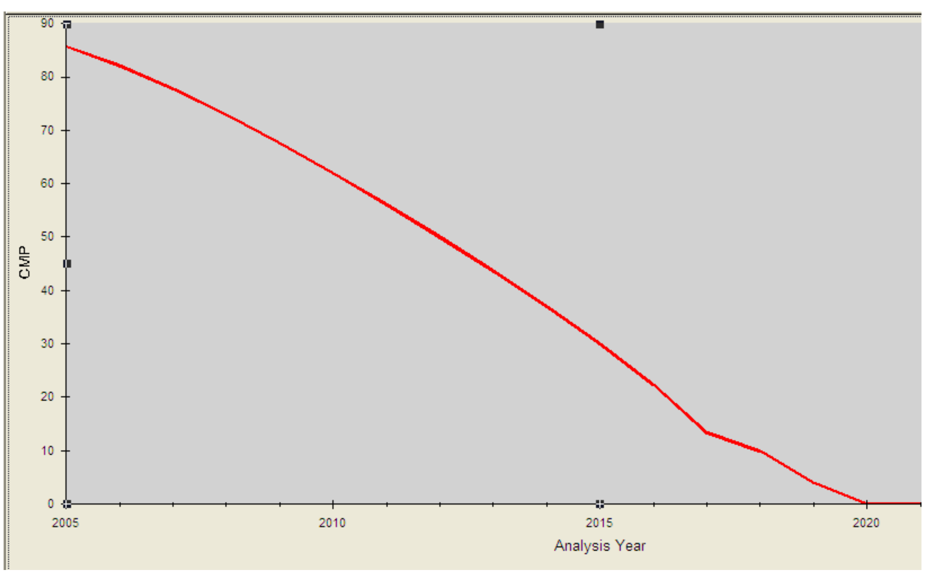


Pavement Deterioration/Investment Curve

The diagram illustrates that early intervention, often in several small efforts, will extend the life of a pavement at a lesser cost than would be necessary if it were allowed to become in Poor or Very Poor condition. Many homeowners have the experience of frequently coating their paved drive, resulting in extended time before major work. The same strategy applies to highways.

Knowing the date of last work on a segment or simply knowing its condition in terms of amount and severity of cracking, rutting, roughness, pot holes, etc., we can predict when its condition(s) will fall within a trigger zone for one of the available treatments.

Based on many years of data accumulated by VTrans, we are comfortable in our belief that most of Norwich's paved roadways will have a deterioration (performance) curve as illustrated in the following figure for a town highway. Certainly some roads will perform better (survive longer) and some less so, but with the data currently available this model will serve well for predicting the need for treatment.

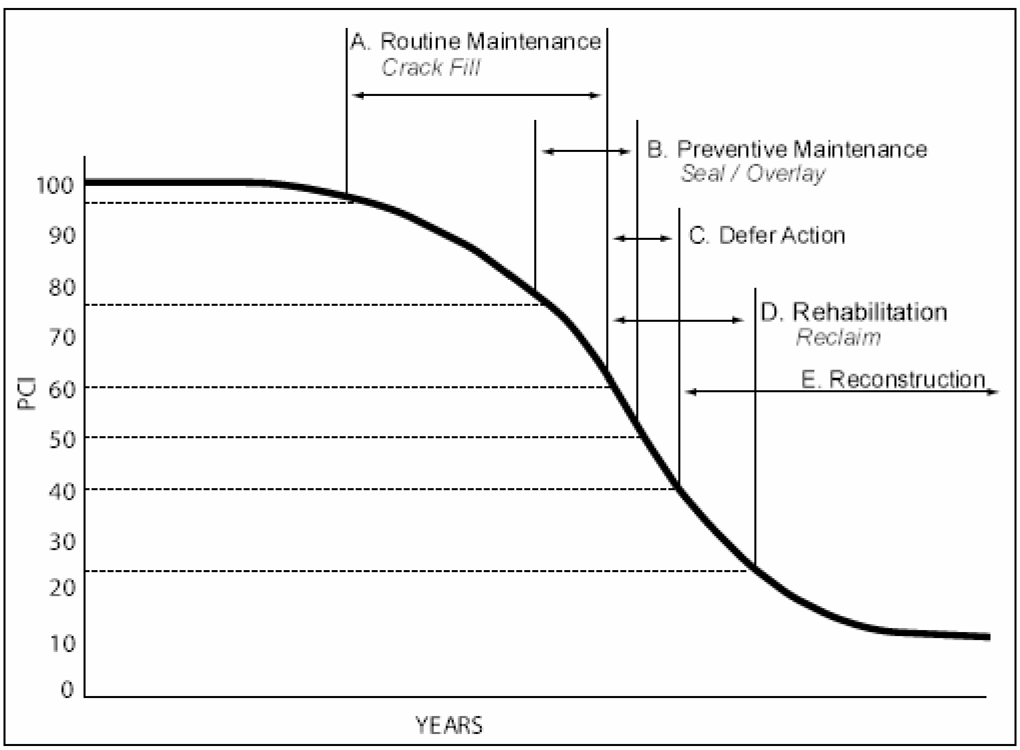


Composite Performance Curve

For our analysis we used a performance curve for each of the surface characteristics (alligator cracking, etc), but with several added inventory efforts we could estimate the quality of the road structure underlying the pavement in each segment, and prepare a performance curve for other than this generalized roadway.

Knowing how the total roadway structure is likely to perform, along with its current condition and predicted condition, one or a series of treatments may be evaluated.

The following figure illustrates where typical treatments apply over the life of a pavement. Note the overlap of treatments, illustrating that pavement treatment selection is not rigid and recognizing that the highway superintendent will make a sensible choice among the available treatments, based on personal observation of roadway conditions within the project area.



Treatment and Condition Relationship

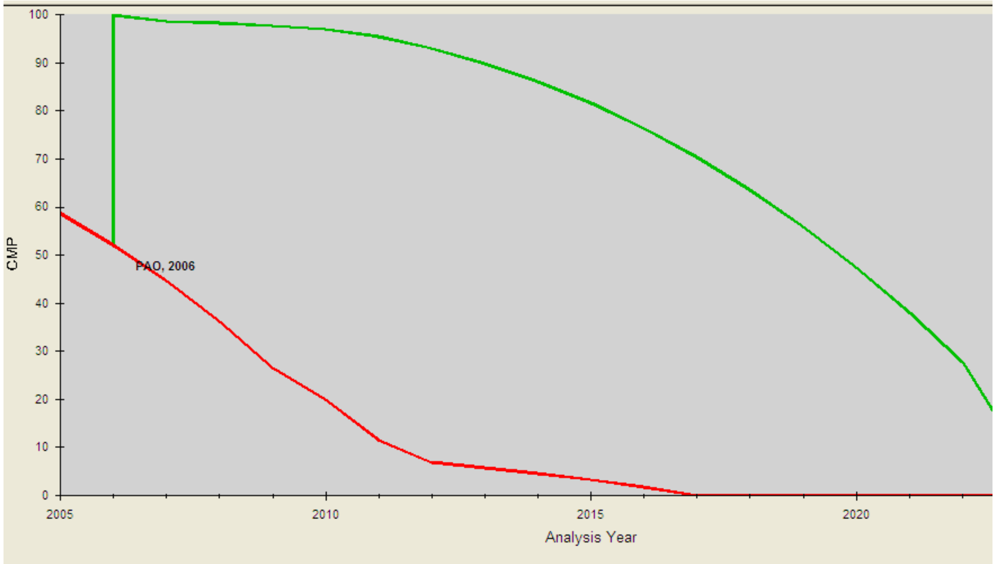
For example, a pavement could receive a seal treatment and extend its life by 5-8 years, or a structural overlay could extend the life by 8-12 years, or if so indicated, the roadbed and surface could be reconstructed -- either partially by a reclaim process or wholly by removing and building new from the subgrade.

Good practice suggests that the least costly treatments such as crack filling and surface sealing need to be applied early in the life of the roadway. Delaying treatment invariably leads to the more costly treatments of overlay, reclaim, or reconstruction.

Since each of the treatments (crack filling, seal, overlay, etc.) has a different unit cost, selection is a matter of performance vs cost. Since the treatments are in the future, it is necessary that a discount rate be applied to bring costs back to the beginning year of the analysis.

The anticipated state of each characteristic (alligator cracking, longitudinal-transverse cracking, rutting, etc.) in a future year, suggests the appropriate treatment.

In the following figure, the expected deterioration (shown in composite of all the characteristics) of the existing pavement is shown in red. The completion of a reclaim and overlay project (suggested by the condition rating and the distresses found by the inventory), would result in the performance curve shown in green.



Performance with Reclaim project in 2006

- Program Development Procedure

  We recommend that the following variety of treatments be considered:

  Crack filling
  Sealing
  Overlay
  Reclaim
  Reconstruction

The dTIMS system has information on the expected quality improvement and effective life for each of these treatments.

The following listing indicates the estiamted cost for each of the treatments being considered, based on recent unit prices for the work involved:

Sealing	$5.50 /SY
Overlay	$10.25 /SY
Reclaim	$17.50 /SY
Reconstruction	$25.00 /SY

The dTIMS system developed a deterioration curve for each of Norwich's 111 paved roadway segments. The placement in time for each deterioration curve is based on segment condition indicated by the 2006 RSMS survey.

The curve is reviewed (electronically) to determine when a treatment is within the trigger limits for its use. Treatments are selected with the following considerations:

a. **Crack filling** is typically applied 3 years after the new condition and may be repeated in two years
b. **Seal** is applied when cracking is developed to beyond reasonable crack filling efforts.
c. **Overlay** is applied when indicated by roughness and moderate cracking combined.
d. **Reclaim** is used when the cracking is severe, and rutting, roughness and edge failure are present, but the subgrade is reasonably firm.
e. **Reconstruction** is indicated if previous overlay or reclaim treatments have failed earlier than expected.

A strategy list for each segment is developed by checking the deterioration curves for each surface characteristic (alligator cracking, longitudinal-transverse cracking, edge cracking, rutting, and roughness) and noting when the expected surface conditions suggest a treatment.

The following table contains the type of treatment, treatment year and cost per mile over the 10 years of analysis for an arbitrary segment.

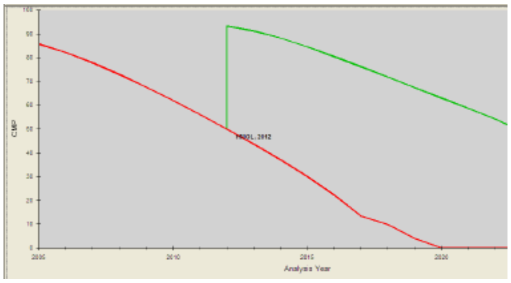
TREATMENT	TREATMENT YEAR	TREATMENT COST
SEAL	2009	$65,000
SEAL	2010	$65,000
SEAL	2011	$65,000
SEAL	2012	$65,000
OVERLAY	2013	$120,000
OVERLAY	2014	$120,000
OVERLAY	2015	$120,000

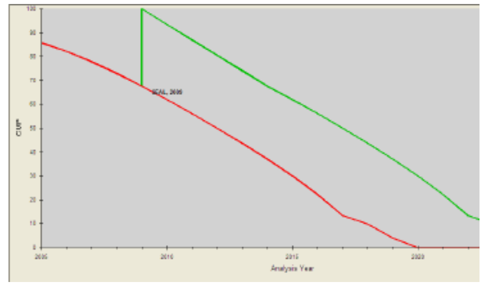
Treatment costs assumed are based on 2006 prices. Future project budgets must be adjusted based on prices current at that time.

Note that the cost for a treatment is constant. An inflation factor could be applied to assist in budgeting, but for comparison purposes our analysis uses present-value costs. Also, bid prices over the last five years have not shown a consistent pattern and we expect price fluctuation to continue in the future. Town officials should evaluate current experience with prices and adjust budgets to compensate for the expected cost of projects scheduled in the next following budget year.

The following two figures illustrate the effect on performance relative to applying a seal and an overlay. Note that the roadway condition declines to a larger degree before the overlay treatment, but the added strength from the overlay pavement flattens the performance curve;

while the seal, having added no appreciable strength, follows the original curve. Repeating the seal at around 2015 would essentially recreate the same performance as the overlay.


Overlay in 2013


Seal in 2008

The dTIMS system selects the most efficient year and treatment for use of the available funds and includes the project in the annual program for that year. For the segment illustrated above, the system selected Seal in 2008 as the most efficient treatment (economically).

In some cases, the segment(s) in worse condition will not be selected. This occurs because treatment selection is based on the effective use of funds to gain the most years of service for the least total cost over the entire system.

A selected strategy list containing segment name, type of treatment, and cost is prepared by the dTIMS system for each year in the analysis time frame. The projects in the first three years are listed in the program on page 38.

The initial 3-year project list should be reviewed by the Highway Foreman for:

1. Reasonable selection of type treatment
2. Timing to accommodate other work
3. Need to add funds for ancillary drainage, guard rail, etc

- Program Adjustment

When suggested by town management, the treatment strategy suggested by dTIMS is adjusted in terms of type and timing and this choice is “adjusted” in the dTIMS system. The system analysis is run again.

The selections for the “adjusted projects” is considered to be “committed” while the remaining funds in each year’s budget are used to best advantage in terms of cost-benefit. For example, based on discussion of priority going to Elm Street in 2007, we have committed this work. This results in a new strategy list for each of the other segments in each year and a new program (annual projects) list. This list was used to produce the yearly scheduled projects list (program) found later in this report.

- Looking Ahead

A program (list) of projects was presented to town officials for ten years, but we strongly advise that surface conditions be again inventoried in 2010 and the projects listed in the ensuing five years be confirmed as being the best use of funds during that period.

As we noted earlier, our analysis presumed that all segments will deteriorate equally. This most definitely <u>*will not*</u> *happen and for that reason all segments should be again evaluated and another analysis made. We are providing the town with our analysis setup and the inventory data in dTIMS format to aid in the future work.*

A future system analysis using dTIMS can be had via an internet-based service from Deighton Associates LTD of Bowmanville, Ontario or from a consultant with the appropriate software.

Routine Maintenance (Crack Filling)

Asphalt pavement deterioration is caused by several factors. These factors generally occur concurrently and may include:

- Sunlight – causing drying of the asphalt binder
- Temperature change, causing shrinkage cracks usually noted in spring
- Subgrade movement (heaving) due to swelling or freezing. May be due to slipping in the sub-grade.
- Construction defects
- Water – affects asphalt bond to aggregate
- Inadequate subbase
- Wheel loads beyond the design of the base and pavement

Temperature change, subgrade movements, wheel loads, and construction defects all lead to cracks in pavement. *Reflective cracks* generally appear during the second year in a new overlay where underlying cracking is active.

When water intrusion in cracks occurs the following happens:

1. Weakened subbase resulting in longitudinal cracks in wheel tracks
2. Aggravates subgrade movement due to swelling and/or frost action
3. Spread of cracking due to movement at original crack location
4. Pot holes, due to wheel impacts on pavement when water is in cracks

Crack growth is caused by sand particles intruding and preventing crack closure.

Filling cracks offers advantages:

1. Reduces water intrusion
2. Stops sand intrusion

When to fill cracks:

1. Approximately 3 years after new pavement, when crack is wide enough to accept filler and minimal amount of filler material is needed. Use a router and **do not** use a heavy band-aid procedure.
2. Repeat in three years if loss of filler material or experiencing adhesion problems to the sides of the crack.

When not to fill cracks:

1. Where there is Subgrade failure and large crack movement is noted which will not be tolerated by the filler
2. Where cracks are 1-inch or greater. Use cold patch in these.
3. There is a plan to reconstruct the pavement within three years

- VTrans research on effectiveness of crack filling has not been done systematically. It has mostly focused on the failure rate of the filling material under different crack preparation techniques. The attempts to link the filling of cracks to long term ride quality have not been conclusive, due to over-filling being the cause of increased roughness.
- VTrans endorses crack filling as a maintenance technique.

- VTrans has experienced problems with heavy amounts of crack filler becoming involved with an overlay material.

We were pleased to note the quality and amount of crack-filling that Norwich has placed in recent years. It is obvious that only recently has this maintenance effort been done.

Early Intervention

Not much attention has been required (or needed) on surface maintenance and extending the life of the more recent pavements.

Beyond filling cracks an ***Early Intervention*** action to preserve the entire pavement surface is acknowledged to be a more economical approach than waiting for the surface to deteriorate until an overlay or more extensive work is needed.

Early intervention does not mean taking temporary actions, such as patching of pot holes or the smoothing of surfaces by use of a skid box or power grader to place hot mix asphalt. These are stop-gap measures intended to make the roadway usable until a project can address the real problems.

Early intervention means that low-cost work should be done on roadways in a timely manner before they deteriorate and need costly treatment. However, due to budget restraints, it may mean that work on other, even more deteriorated segments may be deferred further.

It is often difficult for the taxpayer to understand that this strategy will save money in the long run, and that it is necessary for sound town administration. In the event of large public concern on specific segments, an occasional deviation from the normal practice may be necessary.

Early Intervention is an action that occurs before the intrusion of water has caused problems in the pavement surface, its base, and in the subbase below the pavement. Basically, an intervention technique provides a thin seal or resurfacing on mildly cracked and somewhat rutted or deformed pavement, at 6 to 8 years after original placing. We refer to these techniques by the general term of ***seals***.

We note with considerable pleasure that the town has already started to practice Early Intervention and placed nearly 3 miles of Rubberized Asphalt seal in 2006.

Seals

Unless the roadbed is particularly weak, use of a thin periodic overlay or *seal* is an economic and viable strategy. Obviously, if the roadbed is weak as evidenced by rutting and/or roughness, then a structural overlay or reclaim/reconstruction treatment is in order.

Some truths about seals:

- A seal must be used timely and management should not wait for the roadway surface to crack significantly nor deform due to water intrusion.
- A seal is an effective and economical wide-area crack-filling treatment and an alternative to heavy and expensive applications of crack filler.
- A seal treatment avoids rebuilding utility inlets and drainage, and preserves curb reveal.

There are a number of both common and proprietary seal techniques and materials. The primary treatments that the town should consider include the following list. Although no order of priority is suggested, the town might make limited trial installations of the new products coming on the market, to achieve some comfort with their cost vs performance relationship.

Recognizing the instability of petroleum product prices we strongly suggest that the town confirm the unit prices noted below before making any decisions.

- **Seal Techniques**

1) Seal with Hot Mix
VTrans Type IV hot mix with Performance Grade Binder placed in one pass, or on a shim if needed. A tamping screed paver is necessary. Use a tack coat of emulsion and maintain one-inch minimum depth. This is the seal technique assumed in our analysis. Cost is $5.50 per SY. Estimated life is 8 to 10 years.

2) Thin Layer Hot Mix (Gorman Brothers Inc.)
Proprietary product NOVACHIP has 5/8 to 3/4-inch surface course placed in one pass on a uniform surface. Cost is $5.50 per SY. Expected life is 8 to 10 years.

3) Micropaving (Gorman Brothers Inc.)
Proprietary technique blends fine stone with asphalt emulsion and is placed with a machine. Can be up to 1-inch depth to fill sags and ruts. Can be placed in two actions as shim and final lift. Black additive may create long life in dark color. Cost is $2.00 per SY for one lift and $3.00 per SY for two lifts. Expected life is 6 to 8 years.

4) Chip Seal (Gorman Brothers Inc.)
In this modernized version of an old technique, pea-size stone is spread on roadway previously coated with polymerized asphalt emulsion. This stone is then sprayed with a "fog coat" of the polymerized emulsion. Cost is $1.75 per SY. Expected life is 5 to 8 years, if plows do not scuff it off earlier.

5) Double Chip Seal (Gorman Brothers Inc.)
This modified version of the chip seal has an added layer of emulsion and stone. Cost is $3.75 per SY. Expected life is 8 to 10 years.

6) Rubberized Asphalt Chip Seal (All States Asphalt, Inc.)
In this modernized version of the old technique, the stone is placed in a layer of hot asphalt binder. The binder asphalt is Performance Grade, same as modern hot mix, and has 10% by volume of granulated rubber from tires mixed into it. The stone itself is heated and coated with the binder in a hot mix plant prior to placing. Resistant to snow plow damage. Cost is $2.20 per SY, plus preparation such as sweeping and shim. Expected life is 8 to 10 years.

7) Stress Absorbing Membrane (All States Asphalt, Inc.)
This modification of the Rubberized Asphalt Chip Seal has 20% granulated rubber in the binder material. May be used as a chip seal, but more effective if covered with 1-inch of hot mix overlay. Advertised to be good at absorbing crack movement. Cost is $3.45 per SY plus

preparation and the HMA overlay, with total cost close to $8.25 per SY. Expected life is 12 – 15 years with overlay.

8) Stress Absorbing Membrane (Gorman Brothers)
This technology is focused on reducing the effects of cracked underlying pavement. Chopped glass fiber is sandwiched between two layers of asphalt emulsion, and this system is covered with a light dressing of small stone. Advertised to bridge cracks and actually to control cracks. . Requires a permanent wearing course. Cost is $2.75 per SY plus the HMA overlay.

Making the choice to use a different paving practice involves economics and expected performance over the same quality subbase material. The selection of a trial project is beyond the scope of this study.

Alternative Resurfacing Techniques

The town has experienced good performance and reasonable prices for its overlays and reclaim projects. This has been largely due the presence of several lay-down firms serving the region.

Alternative techniques that should be considered as options for selected roadways include:

1) Cold Mix Pavement (Gorman Brothers)
An open-graded 3/4-inch minus stone mixture is placed in a 2 ½ -inch lift as base course. This is followed by a 3/8-inch minus stone mixture placed in a 1 ¼-inch top course. The mixture in both layers is bound with asphalt emulsion. The top course must have a wearing surface of hot-mix asphalt or a chip seal. Technique is used by several Vermont communities. Cost is $11.00 to $11.50 per SY including a chip seal wearing surface. Performance is similar to 4-inch Hot Mix, with estimated life of 12 to 15 years.

2) Full Depth Reclamation (Gorman Brothers)
As in the Reclaim technique typically used by the town, this involves breaking up of 8-inches of the existing pavement and subbase material, addition of 2% by volume of Portland Cement and 2% by volume of asphalt emulsion. Requires testing of cores in advance for design of the additives. Trials in Ohio indicate this technique is equal to adding 10-inches of gravel to the reclaiming process. Cost is $5.50 per SY for a minimum of 1-mile of work. A wearing surface is required. Estimated life is expected to be better than hot mix over gravel subbase.

3) Cold In Place Recycling (Gorman Brothers)
Technique involves grinding 4-inches of existing Hot Mix Asphalt and remixing with additives of 2% cement and asphalt emulsions. The mixture is immediately laid down by an integrated and continuous train of equipment, followed by rolling. Use only on moderate grades and curves. Minimum of 1-mile segments. Virtually eliminates reflective cracking. Trials by VTrans have shown good performance. Cost is $5.00 per SY without wearing surface. Estimated life is expected be up to 15 years, the same as hot mix pavement.

Making the choice to use a different paving practice involves economics and expected performance over the same quality subbase material. Occasionally the trial of a new technique is applied to a problem area, possibly not a fair evaluation process. The selection of a trial project is beyond the scope of this study.

Budgeting for Paving

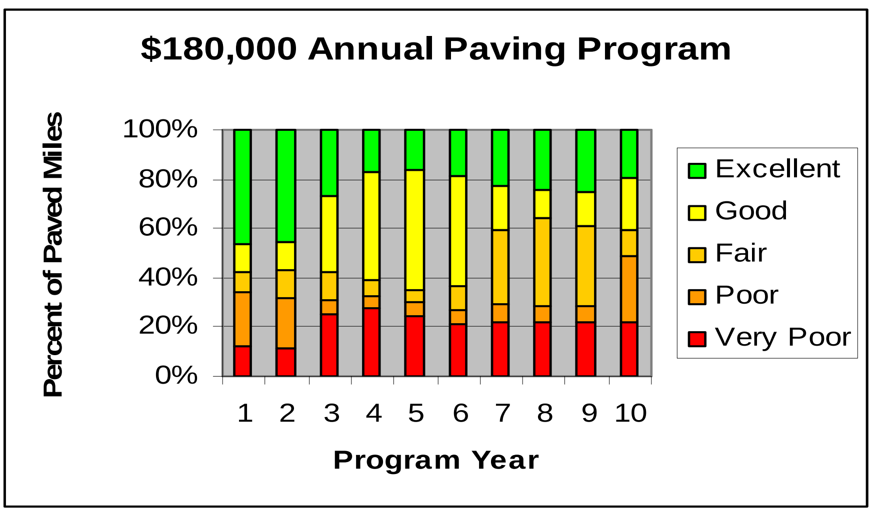
Before a program of projects can be developed we must first know the anticipated amount of funds available in each year of the analysis. The amount is clearly a political decision because the voters are the source of the budgeted funds. Even though budgets are established on an annual basis, the town management needs to look further ahead.

Voter attitude toward spending, and their interest in and support for town infrastructure programs as approved in the past certainly enters into the decision. This reflects, to a large degree, what is their desire for the town; i.e., to stay constant, to achieve a better stance, or to allow a decline in infrastructure condition.

There are various approaches to determining long-term system maintenance budgets. A good approach to arriving at the future budget figure is to look at the health of the system over time with varying budget levels.

We start our analysis with a $180,000 paving budget level, roughly equal to that approved in recent years, and adding $15,000 for crack filling, culvert replacement, and guardrail work within the paving project areas.

The following chart depicts anticipated system condition expressed in percentage of paved miles predicted to be Excellent, Good, Fair, Poor, and Very Poor beginning with the current year (2006) and extending forward for ten years.



Annual program costs assumed are based on 2006 prices. Future program budgets must be adjusted based on prices current at that time.

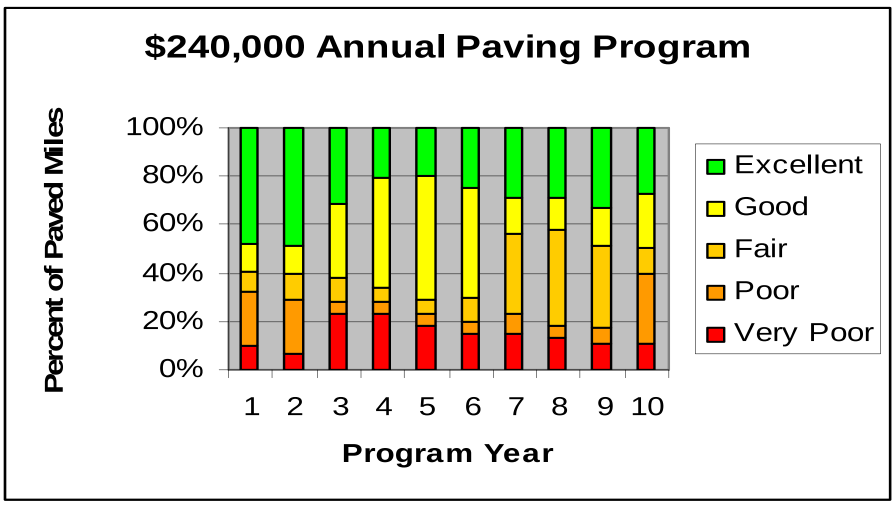
Forecast Condition $180,000 annual

Note that at this budget level there is a slow-paced system improvement in terms of Excellent, Good and Fair mileage, but miles of roadway in Very Poor condition continue to consistently appear at an undesirably high 20% percent of the 33 system miles. This is because segments in Poor condition will degrade to a Very Poor rating, as do segments in higher ratings move downward, while at the same time the large number of miles in best condition are receiving treatments to keep them up.

A fair question is, why not improve right away those roadways in Very Poor condition? We suggest otherwise, primarily due to the fact that we believe that funds available should be used where it will have the most long-term benefit, considering cost and performance, and not treating the *Worst-First.* **That is, we suggest investing in a segment in Good condition before it degrades into Fair or Poor and requires a more costly treatment**.

> *For example, sealing at a cost of $5.50 per square yard provides good surface conditions, which will degrade to about the same as at the treatment date in 8 years. Repeating the seal will gain another 8 years. The alternative is to let the pavement degrade even more and then overlay at a cost of $10.25 per square yard with an expectation of 12 to 15 years. Refer to Figures on page 15 for a pictorial comparison of treatment strategies.*

To seek an appropriate budget, we then examined the effect of a $60,000 increase in the paving program to a $240,000 level. The following chart depicts forecasted system condition with annual paving program spending at that level.



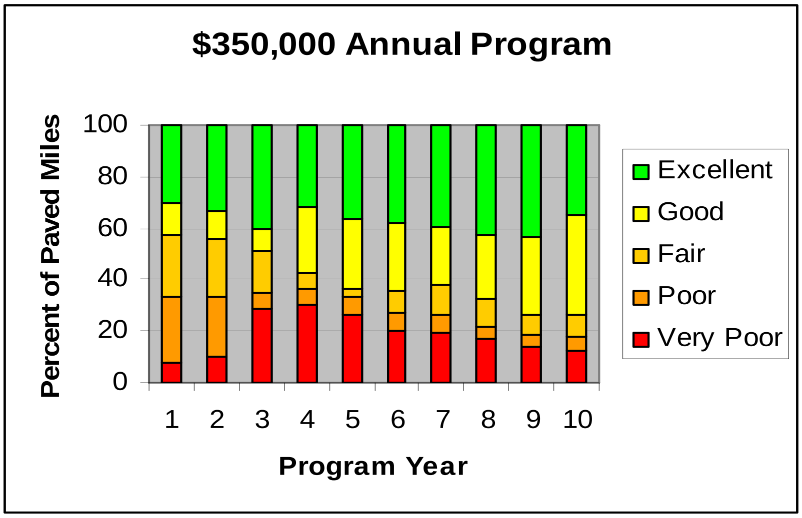
Forecast Condition $240,000 annual

Annual program costs assumed are based on 2006 prices. Future program budgets must be adjusted based on prices current at that time.

Note the general improvement in system condition so that virtually all miles are Excellent, Good or Fair and that mileage in Very Poor condition decreases near the end of the analysis period.

What this means is that the miles now in Excellent-Good-Fair condition are being systematically maintained at a high state and those miles in lower conditions are being improved.

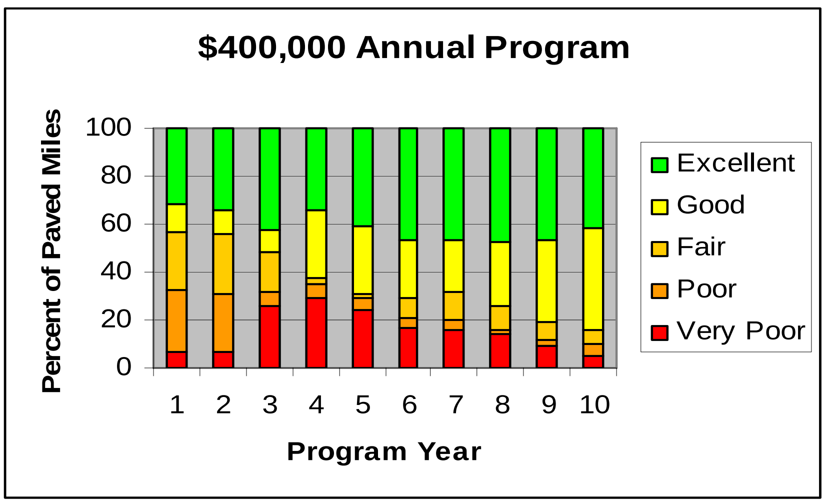
To test our conclusion we analyzed the system condition with an increase in budget to $350,000 annual. In this analysis treatment of Elm Street was committed in 2007 per discussion with town officials. The results are shown in the chart on the next page.



Annual program costs assumed are based on 2006 prices. Future program budgets must be adjusted based on prices current at that time.

Forecast Condition $350,000 Annual

An even greater increase in budget to $400,000 would achieve nearly 90% Excellent or Good condition roadways, and nearly eliminate the Very Poor miles by the end of the 10-year program, as illustrated in the following chart.



Annual program costs assumed are based on 2006 prices. Future program budgets must be adjusted based on prices current at that time.

Forecast Condition $400,000 Annual

- **Conclusion**

We consider that there is little justification to spend a larger annual amount over the long run, and that a $240,000 annual program budget is adequate to maintain a generally constant average condition for the mid-term future.

Alternatively, the Town could adopt a goal that there would be no Very Poor roadways. This would entail funding the paving program at roughly $400,000 annually; or alternatively, committing a large amount in a few early years.

- **Sources of Funding**

Locally raised taxes will normally be the source of funds for the majority of paving work. Very infrequently we have noted towns borrowing long-term for paving projects.

For only the Class 2 town highways, State funds are available infrequently for paving. Grant funds for 2/3 of the cost of Class 2 town highway projects in a year (to $150,000 maximum) may be anticipated on a 3 - 4 year cycle. Obviously, timing the paving work on the Class 2 roadways to match this cycle is beneficial to the town.

We note that Rte 132 is on the federal-aid highway system. As such it is eligible for federal funds to accomplish any desired reconstruction. Securing legislative commitment would be a necessity if this course of action is desired.

Gravel Roads Resurfacing

There are no scientific means to estimate the material that needs to be replaced on gravel-surface roadways, but conventional wisdom, supported by some research, finds that a 1-inch depth of surface gravel is lost per year from a gravel road due to rain, wind and traffic. Failure to replace lost gravel results in a thinner structure with lower load carrying capacity and promise of failure during periods when there is weak roadbed, such as Spring Breakup in Vermont.

The town has approximately 46 miles of gravel roads on the Class 2 and Class 3 system. Roadway width ranges from 12 feet to 24 feet, with majority in 16 – 18-foot range.

Presuming that a width of 18 feet will be resurfaced with 1-inch new gravel suggests a need close to 300 cubic yards (CY) of gravel for resurfacing each mile, or 14,000 CY annually for the town.

From a practical standpoint, one would not try to apply a uniform 1-inch on each mile, but more likely 2-3 inches on a triennial basis. So, this suggests a plan to resurface 15 miles of gravel surface each year, using the 14,000 cubic yards of material. Locally produced crushed gravel will likely cost $6.00 per CY, so the $60,000 typically budgeted by the town falls short of addressing the need.

It should be noted that gravel resurfacing on the Class 2 roads is eligible for state aid; same as hot mix resurfacing, with VTrans grant funds providing 2/3 of the cost.

As an exception, certain gravel roads (or segments) will require more frequent resurfacing than the others, due to their steep grade which causes more than normal erosion, or high traffic volume/speed, and the frequency/amount of chloride applied. The selection of this work would need to be based on past experience in maintaining acceptable surface conditions.

The 2006 RSMS inventory provided a view of overall needs, but cannot be used to effectively manage individual gravel road segments. Clearly, a thunderstorm with localized heavy rain will change the status of a gravel road's surface and drainage overnight. Changes such as this are not predictable, unlike pavement conditions, and the highway managers need the budgets and latitude to make repairs at their discretion.

It is generally accepted that paved roadway surface is warranted where traffic volumes exceed 400 ADT. **We are aware of several roadway segments that easily qualify under this criterion and urge the town to consider paving these**. The segments are located on:

Brookside Drive
Goodrich Four Corners Road
Hawk Pine
Tucker Hill
Willey Hill
Turnpike Road

Culverts and Bridges

Culverts:

The 2006 RSMS inventory identified 739 buried structures or culverts. Interestingly, the great majority of culverts (584) were corrugated steel.

Included were 7 stone box culverts, one of which is in Poor condition and three are Fair.

Included in the buried structures group are 23 with a span of 6-feet or greater, thus being considered bridges for the purpose of state aid. Most of these are in Excellent and Good condition, but three of the 23 large culverts were noted to be in Fair condition due to corrosion.

However, among the smaller structures 53 were found to be in Poor condition. The bulk of these are in the 15" and 12" size.

A larger group of 348 structures were found in Fair condition.

The map on the following page indicates the location and condition of the culverts identified in the inventory.

Nine of the Fair are 36" and larger, costing an estimated $49,500 to replace, and eligible for VTrans 90-10 grant funding.

Considering only the cost of culvert materials, the Poor category would cost close to $18,000 to replace with corrugated steel. If plastic material were used the cost would be approximately 1/3 less.

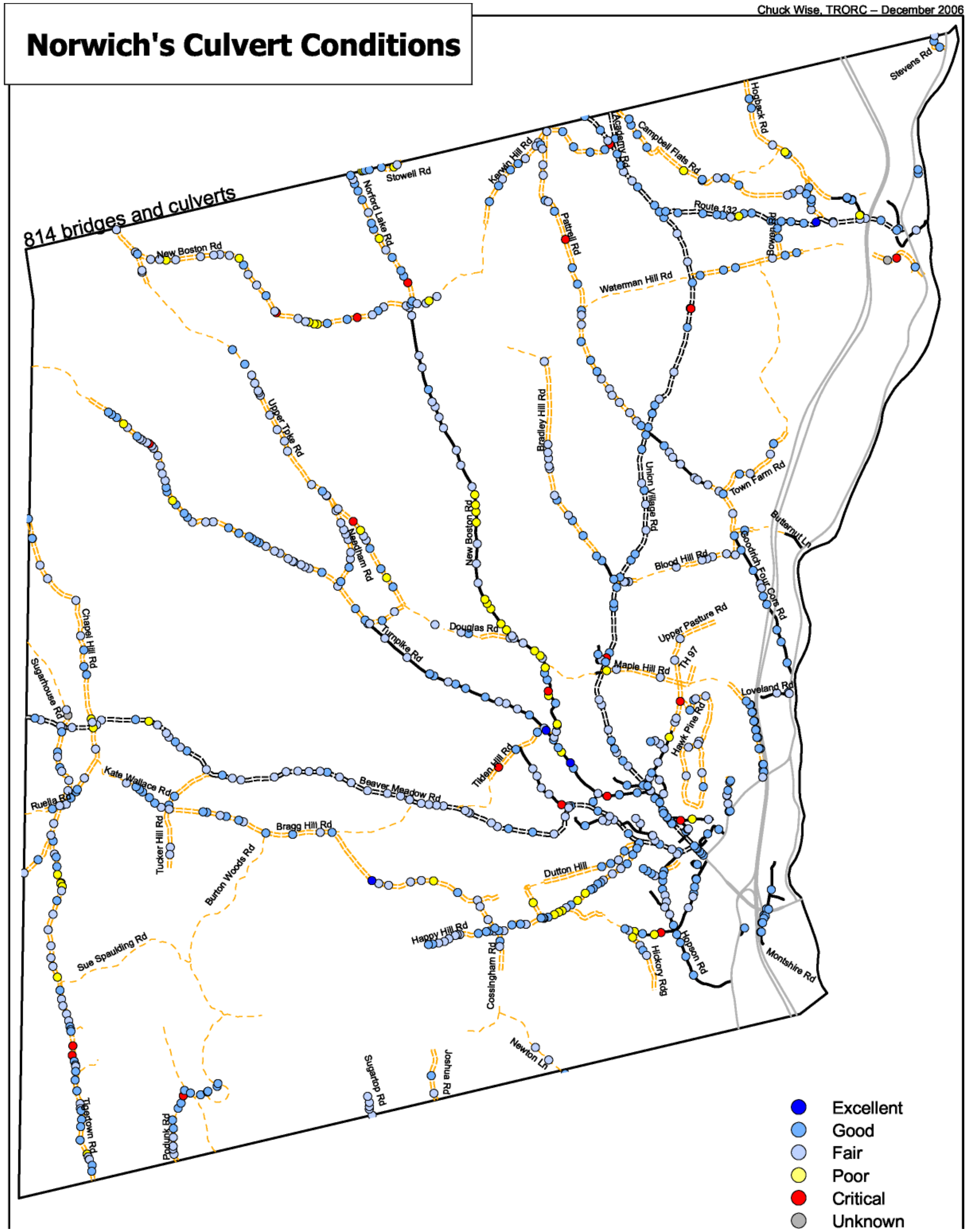
Similarly, the cost to replace those culverts in Fair condition with steel would be close to $215,000.

One aspect of culvert maintenance needs to be mentioned. The 2006 inventory found 30 culverts heavily silted to less than 1/3 remaining opening. Of this group 14 were completely plugged. Clearly, a plugged culvert is not effective and high flow in the ditch is either going to cross the road or erode the shoulder on its way to the next culvert.

We learned that the Road Forman has an active ditching program and plans to install 30 – 40 replacement culverts each year. In the last four years the road crew has installed 120 replacement culverts.

Our recommendations include:

- Continuing the current program to replace culverts in Poor condition. Replacing 30 each year at a cost of $15,000 in materials would be a good program.



Norwich's Culvert Conditions
Chuck Wise, TRORC – December 2006
814 bridges and culverts
Stevens Rd
Hogback Rd
Campbell Flats Rd
Academy Rd
Kerwin Hill Rd
Stowell Rd
Norford Lake Rd
New Boston Rd
Pattrell Rd
Route 132
Waterman Hill Rd
Upper Tpke Rd
Bradley Hill Rd
Union Village Rd
Town Farm Rd
Butternut Ln
Needham Rd
Blood Hill Rd
Goodrich Four Cors Rd
Chapel Hill Rd
Douglas Rd
Upper Pasture Rd
Turnpike Rd
Maple Hill Rd
TH 97
Sugarhouse Rd
Loveland Rd
Hawk Pine Rd
Tilden Hill Rd
Kate Wallace Rd
Beaver Meadow Rd
Ruella Rd
Tucker Hill Rd
Bragg Hill Rd
Burton Woods Rd
Dutton Hill
Happy Hill Rd
Hopson Rd
Montshire Rd
Sue Spaulding Rd
Cossingham Rd
Hickory Rdg
Newton Ln
Joshua Rd
Sugartop Rd
Tigertown Rd
Podunk Rd
Excellent
Good
Fair
Poor
Critical
Unknown

Bridges:

The 2006 inventory identified 19 bridges. Most are in the concrete slab or concrete tee-beam category.

The bridges were all rated as Good or Excellent.

Norwich has aggressively acted to correct its bridge problems. We learned that the state bridge inspection reports are carefully reviewed and appropriate action taken. The Road Forman has been very successful in securing state grants to offset town costs and has effectively used contractors for the heavy work.

Highlights of the reported work since 2002 include:

1. Widen and rehabilitate Br 13 on Beaver Meadow Road
2. Installation of twin Squashed pipes on Happy Hill Road
3. Install Precast concrete box to replace Br 31 on Happy Hill Road
4. Improve entrance to box culvert and stabilize brook on Main Street
5. Widen and rehabilitate Br 10 on Turnpike Road
6. Install Precast concrete box on Bragg Hill Road at Goddard Road
7. Reconstruction of Br 46 on Route 132 (federal aid project)
8. Install Precast concrete box on Bragg Hill Road above Goddard Road
9. Install Precast concrete box on Bragg Hill Road at Happy Hill Road
10. Replaced deck on three Tigertown Road bridges with prefabricated laminated timber deck

Road Foreman Andy Hodgdon is rightly concerned about inadequate stream capacity at culverts and small bridges, and several in the above list were replaced with designed structures supported by hydraulics analysis at VTrans. An inadequate bridge or culvert opening is invitation for washout of the roadway during flood flows, with substantial cost involved.

Hydraulic analysis is required for any bridge or culvert replacement being made with state aid and an acceptable opening must be provided, along with proper environmental measures.

Several culvert locations were reviewed that appear justified for upsizing as opportunity for reconstruction is found, including the structure on Bragg Hill Road in the following photo, which is viewed looking down the grade. Due to grade of the road, overtopping and washout is very likely.

Bragg Hill Road Culvert Inlet

We spot-checked several bridges in the field to verify the inventory condition rating. During this effort we chanced to review Br 39 on Beaver Meadow Road. This is a Precast Concrete Box Beam bridge probably built in the 1960's. Deterioration is evident on the concrete sidewalk as shown in this photo.

Of more concern, from the underside of Br 39 it is obvious that roadway deicing has leaked between one pair of box beams and caused corrosion of the reinforcing steel in the beams with resulting spalling as shown in the following photo:

- We recommend that the town seek a VTrans structures grant for Br 39 to:

    Remove pavement
    Inspect beams for deterioration when the pavement has been removed and patch as appropriate.
    Place an effective membrane on the top of the box beams
    Patch sidewalk concrete
    Place new pavement
    Rehabilitate (clean steel and patch) the underside of the box beams.

- The conditions found on the few bridges that we reviewed suggests that a systematic evaluation effort be made of superstructure and substructure condition on all 42 structures meeting the state definition of a bridge. Based on this a Bridge Improvement Program detailing repair and maintenance work could be developed.

All bridges on paved roadways should be hosed to remove accumulated winter sand and debris from both the concrete surfaces and the structural steel.

- We recommend that there be a systematic annual effort to hose winter sand and debris from the bridges.

Recommendations

A number of suggestions and recommendations have been expressed throughout this report. They are summarized here for the convenience of the reader:

1. Continue the use of high quality designs for paving and related work. In particular, the addition of crushed stone to the reclaimed material is very beneficial.

2. Adopt an attitude of early intervention on the relatively new pavements including systematically crack-filling and sealing.

3. Accept the premise of several low-cost/shorter-lived treatments applied early in the life-span of a pavement as being preferable to allowing advanced deterioration and a costly recovery strategy.

4. Provide a higher level of funding for paving and related work with priority to preserving the investment already made.

5. Monitor system and paved segment condition by periodic inventories and analysis, followed up by policy and program adjustments as seen appropriate at that time.

6. Be open-minded but cautious on newly developed paving techniques. Make limited trials to confirm that performance is up to predictions and costs are as advertised. Do this with the goal of finding either a better-performing or a more economical product.

7. Affirm and continue with a procedure to replace any culverts in Poor condition, with emphasis on those in advance of paving work.

8. Install/upgrade guard rails in conjunction with paving.

9. Seek a federal-aid project for reconstruction of Ret 132.

10. Provide sufficient bridge funds to allow routine maintenance plus repairs/replacements, using all available state aid.

11. Make a systematic and thorough evaluation of the current condition on all bridge structures and develop a bridge improvement program.

12. Provide systematic resurfacing on gravel roads to preserve roadbed thickness and provide a decent driving surface. Give consideration to paving those gravel roads where traffic volumes exceed 400 ADT.

Capital Program

Paving

This program is based on a budget level of $240,000 per year for paving only, without ancillary costs such as replacement of **Poor** condition culverts in the work area(s).

Note that only the first three years of the long range program are included in this report. The remaining years' programs are on file in the town office.

** indicates is on Class 2 town highway

	Segment	Lgth	Treatment	Pav Cost
2007				
Elm Street	Rte 5 to Bridge 43	0.29	HMOL	32,200
	Br 43 to Hickory Ridge Rd	0.60	HMOL	61,000
	Hickory Ridge to End	0.12	Reclaim	15,800
Hazen Street	Library to Main St	0.20	HMOL	17,800
	Main St to Library	0.04	HMOL	5,300
Lewiston Hill RD	McKenna Rd to End	0.07	HMOL	7,000
New Boston Rd	Pole 39 to	0.47	HMOL	55,900
2008				
Beaver Meadow Rd	Huntley St to MP 1.676	1.50	HMOL	163,000
Union Village Rd	Old Coach Rd to MP 1.592	0.45	Reclaim	87,500
2009				
Beaver Meadow Rd	MP 1.676 to MP 2.594	0.90	HMOL	109,000
Union Village Rd	Main St to Old Coach Rd	1.14	HMOL	124,700

Bridges

2007

Br 39 Beaver Meadow Rd	Design engineering	20,000
Bridges Evaluation and Bridge Improvement Program		7,000

2008

Br 39 Beaver Meadow Rd	Construction	TBD by Design

2009

As Specified by Bridge Improvement Program

Culverts

Year	Activity	Location	Cost
2007			
	Replace 30 culverts	Poor Condition	15,000
2008			
	Replace 30 culverts	Poor Condition	15,000
2009			
	Replace 30 culverts	Poor Condition	15,000