Appendix G

1991 Study and Geotechnical Investigations
IMPROVEMENTS TO
BANNER ROAD AT OLALLA

Prepared for
Kitsap County
Department of Public Works

by
Bovay Northwest, Inc
4040 Wheaton Way, Suite 202
Bremerton, WA 98310
(206)373-7523

October 1991

Bovay Northwest Inc.
October 29, 1991

Mr. Randy Casteel, PE
Kitsap County
Department of Public Works
614 Division Street
Port Orchard, WA 98363

Re: Banner Road Study at Olalla
Bovay Project No. 1847-001

Dear Mr. Casteel,

Bovay Northwest is pleased to submit our study of the southern portion of the Banner Road for your review. The report looks at five various alternatives and provides construction cost estimates, as well as other supporting documentation, for each. The options are tabulated on the attached "Executive Summary."

The study area provided some very challenging road designing circumstances, however we feel we were able to provide a good range of construction options to assist in decision process for this project.

As would be expected with a preliminary investigation for a project of such difficulty, the study raises as many questions as it answers. At this time it would be best that the County review this information and decide if some of the options need refinement, or possibly if additional alternatives need to be considered.

We have refrained from making any specific recommendation in favor of any particular option, since these decisions are best suited to the County's construction prioritization process and the political arena.

Bovay Northwest is very happy to have been able to provide these services for Kitsap County and is willing to assist the County in any of the additional aspects of this project.

Sincerely,

Michael F. Wnek, PE
Project Civil Engineer
## EXECUTIVE SUMMARY

### IMPROVEMENTS TO BANNER ROAD AT OLLALA

<table>
<thead>
<tr>
<th>OPTION</th>
<th>DESCRIPTION</th>
<th>HORIZONTAL ALIGNMENT</th>
<th>VERTICAL ALIGNMENT</th>
<th>CONST. METHOD LEFT</th>
<th>CONST. METHOD RIGHT</th>
<th>PROBLEMS FIXED</th>
<th>PROBLEMS UNRESOLVED</th>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
<th>TOTAL COST 1,000's</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>Change to one-way traffic</td>
<td>Existing</td>
<td>Existing</td>
<td>N/A</td>
<td>N/A</td>
<td>Road width Guard rail</td>
<td>Steep grade Abrupt crest</td>
<td>Least cost</td>
<td>Traffic confusion</td>
<td>$ 481</td>
</tr>
<tr>
<td>#2</td>
<td>Standard roadway design</td>
<td>Existing</td>
<td>Modified</td>
<td>Flatten slopes</td>
<td>Flatten slopes</td>
<td>Road width Guard Rail</td>
<td>Modify crest</td>
<td>Steep grade</td>
<td>Least cost for two-lane options</td>
<td>drastic beach encroachment</td>
</tr>
<tr>
<td>#3</td>
<td>Modification of Option #2</td>
<td>Existing</td>
<td>Modified</td>
<td>Shotcrete</td>
<td>Shoulder retaining wall</td>
<td>Road width Guard Rail</td>
<td>Modify crest</td>
<td>Steep grade</td>
<td>Minimize right-of-way</td>
<td>Requires retaining wall const. on steep slopes</td>
</tr>
<tr>
<td>#4</td>
<td>Shift work away from breaks of Clovis Passage</td>
<td>Shifted to north</td>
<td>Improved</td>
<td>Flatten slopes</td>
<td>Minimal work</td>
<td>Road width Guard rail</td>
<td>Steep grade Remove crest</td>
<td>None</td>
<td>Fixes all deficiencies</td>
<td>3 houses must be taken</td>
</tr>
<tr>
<td>#5</td>
<td>Shift work towards Clovis Passage side</td>
<td>Shifted to south</td>
<td>Improved</td>
<td>Shotcrete</td>
<td>30' high concrete sea-wall</td>
<td>Road width Guard rail</td>
<td>Steep grade Remove crest</td>
<td>None</td>
<td>Fixes all deficiencies w/o taking any houses</td>
<td>highest cost</td>
</tr>
</tbody>
</table>
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>SECTION</th>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>OVERVIEW</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>PROJECT DESCRIPTION</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>VICINITY MAP</td>
<td>Figure-A</td>
</tr>
<tr>
<td></td>
<td>CONSTRUCTION ALTERNATIVES SUMMARY</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>DESIGN CRITERIA</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>COST FACTORS</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>DISCUSSION OF CONSTRUCTION ALTERNATIVES</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>CONCLUSIONS</td>
<td>11</td>
</tr>
<tr>
<td>2</td>
<td>PLANS &amp; PROFILES</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Profile, Option #2 &amp; #3</td>
<td>Figure-B</td>
</tr>
<tr>
<td></td>
<td>Plan, Option #2</td>
<td>Figure-C</td>
</tr>
<tr>
<td></td>
<td>Plan, Option #3</td>
<td>Figure-D</td>
</tr>
<tr>
<td></td>
<td>Profile, Option #4 &amp; #5</td>
<td>Figure-E</td>
</tr>
<tr>
<td></td>
<td>Plan, Option #4</td>
<td>Figure-F</td>
</tr>
<tr>
<td></td>
<td>Plan, Option #5</td>
<td>Figure-G</td>
</tr>
<tr>
<td>3</td>
<td>TECHNICAL DATA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cost Estimate, Option #1</td>
<td>Figure-H</td>
</tr>
<tr>
<td></td>
<td>Cost Estimate, Option #2</td>
<td>Figure-I</td>
</tr>
<tr>
<td></td>
<td>Cost Estimate, Option #3</td>
<td>Figure-J</td>
</tr>
<tr>
<td></td>
<td>Cost Estimate, Option #4</td>
<td>Figure-K</td>
</tr>
<tr>
<td></td>
<td>Cost Estimate, Option #5</td>
<td>Figure-L</td>
</tr>
<tr>
<td></td>
<td>Roadway Template 1</td>
<td>Figure-M</td>
</tr>
<tr>
<td></td>
<td>Roadway Template 2</td>
<td>Figure-N</td>
</tr>
<tr>
<td></td>
<td>Roadway Template 3</td>
<td>Figure-O</td>
</tr>
<tr>
<td></td>
<td>Roadway Template 4</td>
<td>Figure-P</td>
</tr>
<tr>
<td></td>
<td>STA 15+50 Cross-Section, Option #2</td>
<td>Figure-Q</td>
</tr>
<tr>
<td></td>
<td>STA 15+50 Cross-Section, Option #4</td>
<td>Figure-R</td>
</tr>
<tr>
<td></td>
<td>STA 17+50 Cross-Section, Option #2</td>
<td>Figure-S</td>
</tr>
<tr>
<td></td>
<td>STA 17+50 Cross-Section, Option #3</td>
<td>Figure-T</td>
</tr>
<tr>
<td></td>
<td>STA 17+50 Cross-Section, Option #4</td>
<td>Figure-U</td>
</tr>
<tr>
<td></td>
<td>STA 17+50 Cross-Section, Option #5</td>
<td>Figure-V</td>
</tr>
<tr>
<td></td>
<td>WSDOT Retaining Wall, Type 2 (Standard Plan D-2e)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>WSDOT Retaining Wall, Type 3 (Standard Plan D-2f)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>SOILS REPORT</td>
<td></td>
</tr>
</tbody>
</table>
OVERVIEW

This report has been prepared by Bovay Northwest, Inc. of Bremerton for Kitsap County Public Works, as a preliminary investigation of reconstruction alternatives for the subject road. Bovay was assisted by Robert McGinnis and Associates of Port Orchard for the field survey work; and Shannon & Wilson of Seattle for the soils and geotechnical support.

Section 1 of this report contains the discussions of the various options and the basis for determining the options. Section 2 shows the horizontal and vertical alignments proposed for each option. Section 3 contains the technical data in support of the options. Section 4 contains a copy of the soils report.

For clarity, the "figures" used in Sections 1, 2, & 3 use a letter designation, the "figures" in Section 4 have a numeric designation.

PROJECT DESCRIPTION

This study investigates the Banner Road (Kitsap County Road No. 32309) from its intersection with the Olalla Valley Road at Olalla for 1,100 feet to the east. The project is located in southeastern Kitsap County, and is bordered on the south side by Colvos Passage, a portion of Puget Sound.

Although the study area is short, the roadway is subject to a variety of deficiencies. The roadway climbs abruptly along steep sidehill terrain, with grades up to 15%. The total road width averages 18-feet and suffers from the encroachment of sloughing soils from the steep cut slopes, and the erosion of fill material by the wave action of Colvos Passage.

Some settling of fill material has occurred along the south shoulder of the road between STA 14+00 to 15+00. This area has also been the site of some minor landslides in the past, and water seepage along the cut slope is evident year-round. The Soils Report concludes that these soil problems can be corrected by protecting the toe of the slope with a sea-wall to prevent further erosion, and controlling the subsurface water.

Beyond the east end of the project, the roadway makes an abrupt S-curve. Realignment of this situation is not addressed by this report, since the deficiencies listed in the above paragraph were determined to be the immediate problems of concern.
There are 4 houses, and 1 business within close proximity to the roadway. Although it is not desirable to purchase houses and re-locate families for public works projects, government entities are responsible to their constituents to construct public projects for maximum benefit with the least costs to the general public. Therefore it is necessary, for this report to be complete, to look at options that require condemnation; and compare the cost to other options.

CONSTRUCTION ALTERNATIVES SUMMARY

Various roadway designs were placed on a topographic model created from the field survey information, using geometric and operational parameters described under "Design Criteria" on page 4. Construction quantities were determined from the designs and developed into a total construction cost estimate, using the documentation described under "Cost Factors" on page 6.

The roadway designs shown within this report are not intended as final construction plans. The alignments and grades shown were devised to create workable solutions, and may need to be adjusted slightly before producing construction drawings. However, the quantities derived from these designs are accurate enough to provide documentation for determining the most suitable option to select.

Option #1 - With no changes to the existing horizontal and vertical alignments, provide traffic revisions that will make the Banner Road a one-way route eastbound. Westbound traffic would use Culver St (No. 31800) and Price Road (No. 31710); both would also need to be changed to one-way traffic.

Option #2 - Use the existing horizontal alignment, modify the vertical alignment by lengthening the crest vertical curve at STA 16+00 to the maximum distance available. Reconstruct the roadway by deep excavations and embankments so that the backslope and foreslope material is placed on its angle of repose.

Option #3 - Using the same horizontal and vertical alignments as Option #2, reconstruct the roadway by placing a concrete retaining wall below the existing south shoulder, and place a shotcrete application to stabilize the steep cut slopes above the road; in lieu of the massive excavation and embankment created in Option #2.

Option #4 - Shift the horizontal alignment to the north as required so that construction can take place without performing any work on the slope down to the beach. Adjust
the vertical alignment to remove the steep grade and abrupt cresting curve. Excavate the uphill side of the road to flatten it to its angle of repose, and haul the material away to be wasted or incorporated into another project.

Option #5 - Shift the horizontal alignment to the south, provide additional road width by constructing a concrete seawall at beach level. Adjust the vertical alignment to remove the steep grade and abrupt crest, similar to Option #4. Excavate on the uphill side only as necessary to provide road width, and apply shotcrete to the steep cut slopes.

Option #1 makes no improvement to the vertical alignment. Options #2 & #3 modify the crest vertical curve at STA 16+00 so that it meets the "stopping sight distance" criteria for a 30 mph design, but retains a short length of 14% grade. Options #4 & #5 totally removes the crest vertical curve at STA 16+00, providing a steady 8% grade. These profile differences can be seen by comparing Figure-B with Figure-E. The changes to the horizontal alignments between alternatives are more subtle, but still cause some drastic changes to the construction limits. Options #1, #2, & #3 follow the existing centerline as much as practical; Options #4 & #5 delete the curve near STA 14+00, and make adjustments to the last two curves, and the tangent in between, to place the roadway in its most suitable location. The shift in horizontal alignment is best portrayed by Figures-S, -T, -U, & -V which show the corresponding changes in construction for each option at STA 17+50.

DESIGN CRITERIA

Due to the short length of project, it was not possible to assign overall design speed criteria. The intersection with the Olalla Valley Road at the western end and the S-curve combination at the east end, in conjunction with the general topography, limited the design criteria.

Option #1 which use the existing horizontal and vertical alignment has less than a 25 mph design speed due to the steep grade and abrupt vertical crest. Modification of the vertical alignment in Options #2 & #3 increases the vertical sight distances to a 30 mph design speed. Even with the improved vertical alignment in Options #4 & #5, horizontal sight distance at the second curve becomes the limiting factor, resulting in a design speed of 35 mph. The S-curve at the east end of the project area is limited to 15 mph traffic speeds, making this discussion of design speeds somewhat academic; however the design speeds attainable do provide some comparison between the alternatives.

The Soils Report (Section 4) recommends using a maximum of 2:1 slopes to fully stabilize the native materials. However, all
designs for this study use a 1.5:1 angle of repose, since it is
felt that these materials will remain stable at the steeper slope
as long as the slopes remain properly vegetated. The use of 2:1
slopes creates some vary drastic construction limits.

The road is classified as a minor collector on the state roadway
system. Design standards recommend a roadway width of 22-feet with
6-foot shoulders (34-feet total) for new construction, and range
down to 22-feet with 2-foot shoulders for rehabilitation. The
County elected to specify a 22-foot roadway with 3-foot shoulders
(28-foot total width) for this project.

The guard rail system selected for use in the design options is
pre-cast concrete barrier, since standard beam rail would allow too
much deflection for some of the options considered, particularly
when used in conjunction with an adjacent retaining wall. Use of
the concrete barrier guard rail system requires six additional feet
of shoulder width.

The design of rural roads normally includes an open ditch in areas
of cut, however it was decided to eliminate the ditch section, and
the additional construction width it requires, to economize on the
excavation requirements. Furthermore the soils report recommends
a subsurface drain to cut-off ground water, therefore it was felt
that the drainage requirements for this roadway could be met
through a combination of the sub-surface drains and concrete
curbing. Since one of the major priorities for any construction
work in this area is to stabilize the slopes, open ditches will not
necessarily be required to catch loose material sloughing from the
cut slopes. The curbing only requires one additional foot of
shoulder width, as opposed to 8 to 10 feet for a ditch section.

There are various materials used currently for retaining walls,
depending on the application. However in order to correlate the
designs and provide consistency in the cost estimates, it was
elected to use concrete retaining walls for dimensions, quantities,
and costs, based on the Washington State Department of
Transportation standard plans. Copies of the Standard Plans D-2e
and D-2f are included in Section 3. It should be noted that
Standard Plan D-2f recommends a maximum slope of 1.75:1 above the
retaining wall, whereas a 1.5:1 was used in all designs. Any
option selected for construction that uses concrete retaining walls
would need to be further investigated to assure that the walls
would function at this slope, and that foundation dimensions would
be compatible with soil conditions.

Some of the Options use a shotcrete application to stabilize steep
upper cut slopes as opposed to excavation of the slopes back to
their angle of repose. Shotcrete (gunite) is a concrete mixture
that is sprayed into position on a slope; a typical application is
shown in Figure-12 of the Soils Report. (Section 4.)
For sea-walls whose only purpose is to protect the slope from erosion by wave action, a rockery sea-wall was used; a schematic is included in Figure-13 of the Soils Report. Sea-walls that needed to provide soil retention as well as slope protection use a concrete retaining wall as per the WSDOT walls.

The various roadway templates used for the design and quantity estimation are included in Section 3, Figures-M, -N, -O, & -P. Template 1 (Figure-M) was used at both ends of the project for all alternatives, the other templates were used for the central portion of the project to achieved the desired construction results. The specific templates used for each alternative are labelled on the Profile drawings, showing their respective stationing ranges. All designs assume a roadway structural section of 1-foot in depth, and all earthwork quantities are calculated to this 1-foot deep "subgrade" elevation.

**COST FACTORS**

In order to provide a good comparison between alternatives, cost factors need to be standardized between the designs. Item costs were determined using: typical local contract bid prices, information supplied by the County, or discussions with contractors.

If the same material was used on different alternatives, in a different application that would result in a higher construction cost it was delineated into separate categories. A typical example is the concrete retaining wall. Although the same basic wall would be used on dry-land as opposed to a sea-wall, construction is more difficult on a beach site and likewise more expensive.

Similarly, excavation was broken down into three categories: "excavation for balance"," borrow excavation" and "excavation & waste." The same cost was used for borrow and balance excavation, reasoning that if the project ran short of embankment materials the excavations could be widened as required. However, options with a surplus of excavation would need to have material hauled away to be wasted, since arbitrary widening of fill slopes within the project limits is not feasible, and therefore any excavation that needs to be wasted must carry a higher cost.

Right-of-way land costs were determined using their current assessed values, with an inflation value and closing fees added on. However, the assessed land values varied greatly, from $18,000 per acre to $173,000 per acre. These values were calculated to a standard land value of $40,000 per acre for use in the estimates. Right-of-way costs were not broken down by parcel.
Houses that needed to be purchased, use the direct assessment value (no averaging); with an inflation value, closing fees, and relocation costs added on.

Since it was not the intent of this report to produce final construction documents, it was not practical to define all construction categories in the cost estimate; and the construction estimates are based on the major items. However in order to provide the County with an estimate of the total cost of the project, certain multipliers were used, such as:

<table>
<thead>
<tr>
<th>Description</th>
<th>Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miscellaneous minor construction</td>
<td>25% of major construction</td>
</tr>
<tr>
<td>Preliminary engineering</td>
<td>10% of total construction</td>
</tr>
<tr>
<td>Construction Engineering</td>
<td>15% of total construction</td>
</tr>
<tr>
<td>County Administration costs</td>
<td>10% of total project</td>
</tr>
</tbody>
</table>

**DISCUSSION OF CONSTRUCTION ALTERNATIVES**

**OPTION #1**
Profile = None
Plan = Figure A
Typical Cross-Section = None

Option #1 - If funding can not be prioritized for the other alternatives, this option may provide a short term solution. The only immediate requirement to institute this option would be to place concrete barrier and the necessary signing. The existing road width would probably be sufficient as a one-lane road with a concrete barrier. Before this alternative is selected, the Price Road would need to be further assessed, since it suffers from some of the similar problems as the Banner Road within the study limits, such as: steep grade and limited road width.

No plan, profile or typical cross-section are provided for this option; however the one-way routes can be viewed on Figure A, the Vicinity Map.

If this option was considered for any long term solution, it is recommended that the Banner Road be rehabilitated to a standard width, a rockery sea-wall be constructed along the beach for the length of the roadway, and the subsurface water problems be controlled. The Price and Culver Roads may need similar work also, however no cost is included in the estimate for work on these additional roads.

The advantages for this option are that it provides a workable solution for the least cost. It solves some of the highest priority problems such as deficient guard rail, and narrow road width.
The disadvantages would be driver confusion in the short term adapting to the one-way configuration. The local residents might adapt to this fairly quickly, however it would remain confusing in the long term to non-local traffic since it is not an "expected" traffic feature on secondary roads. This option would not solve the problem of steep grade or abrupt vertical alignments, and may not fix the fill stability problems near STA 14+00 unless the work was specifically addressed during the construction.

**OPTION #2**

Profile = Figure B  
Plan = Figure C  
Design Roadway Template 2 = Figure N  
Typical Cross-Section = Figure Q  
Typical Cross-Section = Figure S

Option #2 - This alternative uses basic road design procedures with standard cuts and fills to widen the road along the existing alignments (with some improvement to the vertical alignment) using construction slopes of the material's angle of repose. This alternative is shown mostly for comparative purposes; it may not be realistically considered due to its massive encroachment on the beach. However it was used to provide a basis for some of the other alternatives, and is therefore included as an option. The cross-section shown in Figure-S shows the beach encroachment to be approximately 70-feet at STA 17+50.

The advantages of this option are its cost, since it carries the lowest cost of all the major construction alternatives, and that it provides an improved road width along with the needed guard rail barrier, and makes some improvement to the abrupt crest vertical curve.

Its disadvantages are that it does not improve the steep grade and does not fully improve the abrupt vertical curve crest; along with the environmental impact due to the encroachment on the beach.

**OPTION #3**

Profile = Figure B  
Plan = Figure D  
Design Roadway Template 3 = Figure O  
Typical Cross-Section = Figure T

Option #3 - This alternative uses the same alignments as option #2 but attempts to minimize the property disturbance by the use of retaining walls and shotcrete applications. As opposed to option #2, this alternative is environmentally sound, however the retaining wall design from STA 16+50 to the east would require
special attention due to the steepness of the natural ground, below the existing road. A rockery sea-wall is also required on the beach to protect the slope (and the retaining wall the slope will be supporting) from wave action.

Comparing cross-section Figure-T for Option #3, with Figure-S of Option #2, shows the amount of embankment work saved by constructing the retaining wall.

The advantages of this option are that it provides the least costly two-lane road that is environmentally sound, provides the needed additional road width and guard rail, makes some improvements to the crest vertical curve, and requires the least amount of land disturbance.

Its disadvantages are similar to option #2 in that it will not fully improve the vertical alignment of the roadway. It also risks constructing a retaining wall on a slope of suspect stability.

OPTION #4
Profile = Figure E
Plan = Figure F
Design Roadway Template 2 = Figure N
Typical Cross-Section = Figure R
Typical Cross-Section = Figure U

Option #4 - This alternative has shifted the horizontal alignment beyond STA 16+50 to the north so that no construction needs to take place on the breaks of Colvos Passage, other than a rockery sea-wall on the beach to prevent the slope from further erosion. This alternative also constructs the cut slopes at the angle of repose to stabilize them. However by eliminating any embankment work on the slope below the road, in combination with the large amount of excavation required to stabilize the upper slopes, it creates a vast amount of material that will need to be hauled off the project to be disposed.

This option is the first alternative to fully improve the vertical alignment of the road by removing the vertical crest at STA 16+00, and changing it to a steady 8% grade. However the deep cut required to remove this vertical crest does not allow the driveway approach near STA 16+50 to be re-connected at the same location, and would require a new access at a different location.

It should be noted that the alignment was shifted beyond STA 16+50 only enough to move the construction away from the breaks, leaving the roadway susceptible to sloughing if the sea-wall failed. The roadway must be moved an additional 10 to 20 feet north if the south shoulder of the road was to be at a theoretical 1.5:1 slope down to the sea-wall.
Comparing the cross-sections Figure-Q and Figure-R at STA 15+50 shows that lowering the grade removes the embankment in this area, but requires a larger excavation area above the road. Figure-U at STA 17+50 displays how movement of the centerline deleted any fill requirements over the breaks of Colvos Passage.

The advantages of this option are that it fully improves the vertical alignment of the road by flattening the steep grade and removing the vertical curve crest. It would provide the most stable road of any of the options, by moving the road away from the breaks of Colvos Passage, and flattening all cut slopes to their angle of repose by minimizing the use of retaining walls and shotcrete.

The disadvantages are the major property disturbance that this option would entail, in that 3 houses would need to be taken, along with the largest amount of right-of-way of any of the alternatives other than Options #2. The lot that House-3 is on would need a new access constructed at a different location.

OPTION #5
Profile = Figure E
Plan = Figure G
Design Roadway Template 4 = Figure P
Typical Cross-Section = Figure V

Option #5 - This option provides a variation of Option #4 to minimize property disturbance. It shifts the alignment beyond STA 16+50 to the south and supports the roadway on a 30-foot high concrete sea-wall at beach level. This option also uses shotcrete on the uphill side to stabilize the slopes and further decrease the property disturbance. Figure-V shows a cross-section of STA 17+50 portraying the relationship between the roadway and the sea-wall.

This option provides the same improvements to the vertical alignment as Option #4 yet minimizes the property disturbance, although it still requires a new access road be constructed for House-3 at a new location.

Its disadvantages are mostly in economics, as it is the most costly alternative. The design and construction of an adequately sized concrete retaining wall / sea-wall would present challenging soil and structural engineering designs requiring considerable expertise.
CONCLUSIONS

In order to make a sound decision concerning the appropriate alternative to pursue for this project, two other factors besides initial cost need to be considered by the County. The first item is traffic patterns: weighing the deficiencies of the roadway and substantial cost of correcting these problems, versus other construction needs within its jurisdiction.

The second item would be investment versus useful life. Many of the alternatives call for various retaining structures, a fairly cost intensive item. Generally, structures of this sort are designed for a 35 to 50 year life. An alternative such as Option #3 should be scrutinized to assure that the unresolved roadway deficiencies could be tolerated for such a long time span.

Option #4 appears to be a more cost-effective alternative than Option #5, however it involves the condemnation of 3 houses. Before this alternative can be selected, a more detailed looked at the right-of-way needs should be considered. The condemnation of House-1 and House-2 would most likely require the purchase of the entire subdivision lot these houses are situated on, and right-of-way for the estimate is based on land within the construction limits only. Also the right-of-way cost estimates are based on an standard land value throughout the project, and may need to be broken down by parcel to refine the estimates.

In consideration of traffic flows, Option #4 may provide a method of realigning the S-curve at the east end of the study area, although this problem was not specifically considered as part of this report. However further movement of this road to the north, to realign the S-curve, will probably entail additional costs in excavation and right-of-way; increasing the cost of this alternative closer to Option #5.

An additional option to consider may be to combine the advantages of some of the various alternatives to a sixth option. The use of the uphill side of Option #5, with the horizontal alignment and south side of Option #4 may produce construction limits that require condemning fewer houses.

One other point to consider that is not fully evaluated in this report, is the effect of house values by movement of the roadway closer to the houses, when the houses are not being condemned. Although Options #2, #3, & #5 do not require the take of any houses, they move the north shoulder of the road 5 to 10 feet north and place the construction limits within 15-20 feet of House-1 and House-2. Any damages to property values created by any of these alternatives could only be defined through an appraisal; no attempt was made to estimate any such damages for this report.
In closing, this project entails making some tough decisions; however it must be remembered that the nature of project area does not afford any easy solutions, which is the prime reason why these problems were not solved in past years.
FIGURE H

OPTION #1 COST ESTIMATE

KITSAP COUNTY
BANNER ROAD STUDY @ OLALLA

<table>
<thead>
<tr>
<th>ITEM DESCRIPTION</th>
<th>COST / UNIT</th>
<th>QUANTITY</th>
<th>TOTAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>RIGHT-OF-WAY = LAND</td>
<td>$40,000.00 / ACRE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RIGHT-OF-WAY = HOUSE 1</td>
<td>$70,000.00 / EACH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RIGHT-OF-WAY = HOUSE 2</td>
<td>$70,000.00 / EACH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RIGHT-OF-WAY = HOUSE 3</td>
<td>$80,000.00 / EACH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLEARING &amp; GRUBBING</td>
<td>$3,000.00 / ACRE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXCAVATION FOR BALANCE</td>
<td>$3.00 / C.Y.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BORROW EXCAVATION</td>
<td>$3.00 / C.Y.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXCAVATION &amp; WASTE</td>
<td>$5.00 / C.Y.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DRAINAGE</td>
<td>$30,000.00 / L.S.</td>
<td>1</td>
<td>$30,000.00</td>
</tr>
<tr>
<td>SHOTCRETE</td>
<td>$15.00 / S.F.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SURFACING</td>
<td>$15.00 / C.Y.</td>
<td>1,500</td>
<td>$22,500.00</td>
</tr>
<tr>
<td>ASPHALT CONCRETE PAVEMENT</td>
<td>$32.00 / TON</td>
<td>500</td>
<td>$16,000.00</td>
</tr>
<tr>
<td>PRE-CAST CONCRETE BARRIER</td>
<td>$20.00 / L.F.</td>
<td>764</td>
<td>$15,280.00</td>
</tr>
<tr>
<td>CONCRETE RETAINING WALL</td>
<td>$200.00 / C.Y.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONCRETE SEA-WALL</td>
<td>$400.00 / C.Y.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROCKERY SEA-WALL</td>
<td>$400.00 / L.F.</td>
<td>490</td>
<td>$196,000.00</td>
</tr>
</tbody>
</table>

| CONSTRUCTION MISCELLANEOUS        | 25% * CONST  |          | $69,945.00 |
| PRELIMINARY ENGINEERING          | 10% * CONST  |          | $34,972.50 |
| CONSTRUCTION ENGINEERING         | 15% * CONST  |          | $52,458.75 |
| COUNTY ADMINISTRATION            | 10% * TOTAL  |          | $43,715.63 |

TOTAL COST: $480,871.88
## FIGURE I

### OPTION #2 COST ESTIMATE

**KITSAP COUNTY**  
**BANNER ROAD STUDY @ OLALLA**

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Cost / Unit</th>
<th>Quantity</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right-of-Way = Land</td>
<td>$40,000.00 / ACRE</td>
<td>2.57</td>
<td>$102,857.67</td>
</tr>
<tr>
<td>Right-of-Way = House 1</td>
<td>$70,000.00 / EACH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right-of-Way = House 2</td>
<td>$70,000.00 / EACH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right-of-Way = House 3</td>
<td>$80,000.00 / EACH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clearing &amp; Grubbing</td>
<td>$3,000.00 / ACRE</td>
<td>3.06</td>
<td>$9,192.77</td>
</tr>
<tr>
<td>Excavation for Balance</td>
<td>$3.00 / C.Y.</td>
<td>18,347</td>
<td>$55,041.00</td>
</tr>
<tr>
<td>Borrow Excavation</td>
<td>$3.00 / C.Y.</td>
<td>20,273</td>
<td>$60,819.00</td>
</tr>
<tr>
<td>Excavation &amp; Waste</td>
<td>$5.00 / C.Y.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drainage</td>
<td>$30,000.00 / L.S.</td>
<td>1</td>
<td>$30,000.00</td>
</tr>
<tr>
<td>Shotcrete</td>
<td>$15.00 / S.F.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surfacing</td>
<td>$15.00 / C.Y.</td>
<td>1,500</td>
<td>$22,500.00</td>
</tr>
<tr>
<td>Asphalt Concrete Pavement</td>
<td>$32.00 / TON</td>
<td>500</td>
<td>$16,000.00</td>
</tr>
<tr>
<td>Pre-Cast Concrete Barrier</td>
<td>$20.00 / L.F.</td>
<td>764</td>
<td>$15,280.00</td>
</tr>
<tr>
<td>Concrete Retaining Wall</td>
<td>$200.00 / C.Y.</td>
<td>36</td>
<td>$7,200.00</td>
</tr>
<tr>
<td>Concrete Sea-Wall</td>
<td>$400.00 / C.Y.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rockery Sea-Wall</td>
<td>$400.00 / L.F.</td>
<td>682</td>
<td>$272,800.00</td>
</tr>
</tbody>
</table>

**Construction Miscellaneous**  
25% * Const  
$122,208.19

**Preliminary Engineering**  
10% * Const  
$61,104.10

**Construction Engineering**  
15% * Const  
$91,656.14

**County Administration**  
10% * Total  
$86,665.89

**Total**

$953,324.76
FIGURE J

OPTION #3 COST ESTIMATE

KITSAP COUNTY
BANNER ROAD STUDY @ OLALLA

<table>
<thead>
<tr>
<th>ITEM DESCRIPTION</th>
<th>COST / UNIT</th>
<th>QUANTITY</th>
<th>TOTAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>RIGHT-OF-WAY = LAND</td>
<td>$40,000.00 / ACRE</td>
<td>0.84</td>
<td>$33,530.76</td>
</tr>
<tr>
<td>RIGHT-OF-WAY = HOUSE 1</td>
<td>$70,000.00 / EACH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RIGHT-OF-WAY = HOUSE 2</td>
<td>$70,000.00 / EACH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RIGHT-OF-WAY = HOUSE 3</td>
<td>$80,000.00 / EACH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLEARING &amp; GRUBBING</td>
<td>$3,000.00 / ACRE</td>
<td>1.33</td>
<td>$3,993.23</td>
</tr>
<tr>
<td>EXCAVATION FOR BALANCE</td>
<td>$3.00 / C.Y.</td>
<td>1,026</td>
<td>$3,078.00</td>
</tr>
<tr>
<td>BORROW EXCAVATION</td>
<td>$3.00 / C.Y.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXCAVATION &amp; WASTE</td>
<td>$5.00 / C.Y.</td>
<td>1,474</td>
<td>$7,370.00</td>
</tr>
<tr>
<td>DRAINAGE</td>
<td>$30,000.00 / L.S.</td>
<td>1</td>
<td>$30,000.00</td>
</tr>
<tr>
<td>SHOTCRETE</td>
<td>$15.00 / S.F.</td>
<td>8,620</td>
<td>$129,300.00</td>
</tr>
<tr>
<td>SURFACING</td>
<td>$15.00 / C.Y.</td>
<td>1,500</td>
<td>$22,500.00</td>
</tr>
<tr>
<td>ASPHALT CONCRETE PAVEMENT</td>
<td>$32.00 / TON</td>
<td>500</td>
<td>$16,000.00</td>
</tr>
<tr>
<td>PRE-CAST CONCRETE BARRIER</td>
<td>$20.00 / L.F.</td>
<td>764</td>
<td>$15,280.00</td>
</tr>
<tr>
<td>CONCRETE RETAINING WALL</td>
<td>$200.00 / C.Y.</td>
<td>862</td>
<td>$172,400.00</td>
</tr>
<tr>
<td>CONCRETE SEA-WALL</td>
<td>$400.00 / C.Y.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROCKERY SEA-WALL</td>
<td>$400.00 / L.F.</td>
<td>490</td>
<td>$196,000.00</td>
</tr>
</tbody>
</table>

CONSTRUCTION MISCELLANEOUS         | 25% * CONST  |           | $148,980.31 |
PRELIMINARY ENGINEERING            | 10% * CONST  |           | $74,490.15  |
CONSTRUCTION ENGINEERING           | 15% * CONST  |           | $111,735.23 |
COUNTY ADMINISTRATION               | 10% * TOTAL  |           | $96,465.77  |

ALL TOTAL..... $1,061,123.46
### FIGURE K

#### OPTION #4 COST ESTIMATE

**KITSAP COUNTY**  
**BANNER ROAD STUDY @ OLALLA**

<table>
<thead>
<tr>
<th>ITEM DESCRIPTION</th>
<th>COST / UNIT</th>
<th>QUANTITY</th>
<th>TOTAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>RIGHT-OF-WAY = LAND</td>
<td>$40,000.00 / ACRE</td>
<td>1.61</td>
<td>$64,270.89</td>
</tr>
<tr>
<td>RIGHT-OF-WAY = HOUSE 1</td>
<td>$70,000.00 / EACH</td>
<td>1</td>
<td>$70,000.00</td>
</tr>
<tr>
<td>RIGHT-OF-WAY = HOUSE 2</td>
<td>$70,000.00 / EACH</td>
<td>1</td>
<td>$70,000.00</td>
</tr>
<tr>
<td>RIGHT-OF-WAY = HOUSE 3</td>
<td>$80,000.00 / EACH</td>
<td>1</td>
<td>$80,000.00</td>
</tr>
<tr>
<td>CLEARING &amp; GRUBBING</td>
<td>$3,000.00 / ACRE</td>
<td>2.10</td>
<td>$6,298.81</td>
</tr>
<tr>
<td>EXCAVATION FOR BALANCE</td>
<td>$3.00 / C.Y.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BORROW EXCAVATION</td>
<td>$3.00 / C.Y.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DRAINAGE</td>
<td>$5.00 / C.Y.</td>
<td>37,327</td>
<td>$186,635.00</td>
</tr>
<tr>
<td>SHOTCRETE</td>
<td>$30,000.00 / L.S.</td>
<td>1</td>
<td>$30,000.00</td>
</tr>
<tr>
<td>SHOTCRETE</td>
<td>$15.00 / S.F.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASPHALT CONCRETE PAVEMENT</td>
<td>$32.00 / TON</td>
<td>1,500</td>
<td>$16,000.00</td>
</tr>
<tr>
<td>CONCRETE RETAINING WALL</td>
<td>$20.00 / L.F.</td>
<td>764</td>
<td>$15,280.00</td>
</tr>
<tr>
<td>CONCRETE SEA-WALL</td>
<td>$200.00 / C.Y.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROCKERY SEA-WALL</td>
<td>$400.00 / C.Y.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **CONSTRUCTION MISCELLANEOUS**    | 25% * CONST   |          | $118,178.45   |
| **PRELIMINARY ENGINEERING**      | 10% * CONST   |          | $59,089.23    |
| **CONSTRUCTION ENGINEERING**     | 15% * CONST   |          | $88,633.84    |
| **COUNTY ADMINISTRATION**        | 10% * TOTAL   |          | $102,288.62   |

**TOTAL**                          |             |          | $1,125,174.85 |
FIGURE 1

OPTION #5 COST ESTIMATE

KITSAP COUNTY
BANNER ROAD STUDY @ OLALLA

<table>
<thead>
<tr>
<th>ITEM DESCRIPTION</th>
<th>COST / UNIT</th>
<th>QUANTITY</th>
<th>TOTAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>RIGHT-OF-WAY = LAND</td>
<td>$40,000.00</td>
<td>1.36</td>
<td>$54,571.17</td>
</tr>
<tr>
<td>RIGHT-OF-WAY = HOUSE 1</td>
<td>$70,000.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RIGHT-OF-WAY = HOUSE 2</td>
<td>$70,000.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RIGHT-OF-WAY = HOUSE 3</td>
<td>$80,000.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLEARING &amp; GRUBBING</td>
<td>$3,000.00</td>
<td>1.86</td>
<td>$5,580.00</td>
</tr>
<tr>
<td>EXCAVATION FOR BALANCE</td>
<td>$3.00</td>
<td>10,175</td>
<td>$30,525.00</td>
</tr>
<tr>
<td>BORROW EXCAVATION</td>
<td>$3.00</td>
<td>4,284</td>
<td>$12,852.00</td>
</tr>
<tr>
<td>EXCAVATION &amp; WASTE</td>
<td>$5.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DRAINAGE</td>
<td>$30,000.00</td>
<td>1</td>
<td>$30,000.00</td>
</tr>
<tr>
<td>SHOTCRETE</td>
<td>$15.00</td>
<td>8,620</td>
<td>$129,300.00</td>
</tr>
<tr>
<td>SURFACING</td>
<td>$15.00</td>
<td>1,500</td>
<td>$22,500.00</td>
</tr>
<tr>
<td>ASPHALT CONCRETE PAVEMENT</td>
<td>$32.00</td>
<td>500</td>
<td>$16,000.00</td>
</tr>
<tr>
<td>PRE-CAST CONCRETE BARRIER</td>
<td>$20.00</td>
<td>764</td>
<td>$15,280.00</td>
</tr>
<tr>
<td>CONCRETE RETAINING WALL</td>
<td>$200.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONCRETE SEA-WALL</td>
<td>$400.00</td>
<td>1,500</td>
<td>$600,000.00</td>
</tr>
<tr>
<td>ROCKERY SEA-WALL</td>
<td>$400.00</td>
<td>100</td>
<td>$40,000.00</td>
</tr>
</tbody>
</table>

CONSTRUCTION MISCELLANEOUS         | 25% * CONST |          | $225,509.25 |
PRELIMINARY ENGINEERING            | 10% * CONST |          | $112,754.63 |
CONSTRUCTION ENGINEERING           | 15% * CONST |          | $169,131.94 |
COUNTY ADMINISTRATION               | 10% * TOTAL |          | $146,400.40 |

----------

ALL TOTAL..... $1,610,404.38
FIGURE N
TEMPLATE NO. 2
1.5:1 CUT LEFT / 1.5:1 FILL RIGHT WITH BARRIER
FIGURE 0
TEMPLATE NO. 3
SHOTCRETE LEFT / SHOULDER RETAINING WALL RIGHT

EXISTING GROUND
SHOTCRETE
1/4:1
FINISHED GRADE
SUBGRADE
(1.0' DEPTH)
CONCRETE BARRIER
CONCRETE RETAINING WALL

1.00  3.00  11.00  11.00  3.00  6.00
15.00  20.00
FIGURE Q
OPTION #2
STA 15+50

SCALE 1=30

EXISTING GROUND
SUBGRADE
58.99
Figure T
Option #3
STA 17+50

Existing Ground

Subgrade 70.19

Scale 1=30
### DESIGN DATA

- **n** = 9
- **f_{c}** = 1200 psi
- **f_{s}** = 24,000 psi
- \( \phi = 32^\circ \)
- **Weight of Backfill** = 180 p.c.f.
- **Weight of Concrete** = 160 p.c.f.

For Sliding Walls

- **H > 1/6** or less
- **L = 1.5(f_{c}) / \phi**
- **W**
  - \( W = W_{f} + W_{s} \) (1/2 + 0.5)
- **W**
  - \( H > 1/6 \)

Moments at toe: tendency to resist overturning must be 2.116 times for H > 1/6 or less 3 times for H > 1/6 or more

**LOADING CONDITION FOR OVERTURNING AND SLIDING**

- **P_{n} = 10^{4} (Collision Load)**
- **E^{2} Surcharge (Ft)**

**NOTES**

Concrete in traffic barrier shall be Class A mix. All other concrete shall be Class B mix.

When wall is constructed in or near salt water, add 1" to thickness, embed steel i'more use Class A concrete in wall.

All reinforcing shall be ASTM A-615, Grade 60.

If the length of wall is between 2 and 30 feet, the expansion joints are less than 6", a special design may be necessary.

For backfill requirements see Standard Pink D-4.

For Wall Surface Treatment see other plan sheets.

### REINFORCED CONCRETE RETAINING WALL

**TYPE 2**: 2" Surcharge or Traffic Barrier

**WASHINGTON STATE DEPARTMENT OF TRANSPORTATION**

**OLYMPIA, WASHINGTON**

**W. A. BULLEY, SECRETARY**

**DESIGN ENGINEER**

**APPROVED**: February 13, 1961

**STANDARD PLAN D-2e**
All concrete shall be Class B Mix. Where wall is constructed in or near salt water, add 1" to thickness, embed steel 1' more and use Class A concrete.

For backfill requirements see Standard Plan D-4.

All reinforcing shall be A.S.T.M. A-615, Gr. 60.

For Wall Surface Treatment see other plan sheets.

DESIGN DATA:
\[ n = 9 \]
\[ f_p = 1200 \text{ p.s.i.} \]
\[ f_s = 24,000 \text{ p.s.i.} \]
\[ \theta = 35^\circ \]

Wt. of backfill= 120 p.c.f.
Wt. of Concrete= 160 p.c.f.

For Sliding, \( S_f = 0.60 \) (Wt. of Concrete + Wt. of Backfill above fig. heel.)

Resultant of loads at or within middle third of footing or moments above it not too tending to resist overturning must be at least two times the moments at or tending to cause overturning. Neglect passive earth pressure \( (P_e) \) in overturning calculations.

Set top of retaining wall back 1/2' for wall heights
\( W \) to 20 ft. For \( W \) above 20 ft use the following formula:
\[ \text{Offset in inches} = \frac{H}{2} \]

Steel reinforcing:

- Bars \( L \) are size % @ 1'-6" ctrs.
- Bars \( O \) are size % @ 1'-6" ctrs.
- Bars \( P \) from a line parallel to front face of wall.
- Vertical line from footing at face of wall.
- Bars \( Q \) are size % @ 1'-6" ctrs.
- Bars \( R \) are size % @ 1'-6" ctrs.
- Bars \( S \) are size % @ 1'-0".

LOADING CONDITION FOR
OVERTURNING & SLIDING

REINFORCED CONCRETE
RETAILING WALL

TYPE 3: 1 3/4:1 Backslope
WASHINGTON STATE DEPARTMENT OF TRANSPORTATION
OLYMPIA, WASHINGTON
W. A. BULLEY, SECRETARY

REINFORCED CONCRETE ENGINEER

C. E. MILLER
SANDS ENGINEERS

APPROVED February 13, 1981

STANDARD PLAN D-21
Geotechnical Report
Banner Road Improvements
Kitsap County, Washington

September 1991

Bovay Northwest, Inc.
4040 Wheaton Way, Suite 202
Bremerton, WA  98310

SHANNON & WILSON, INC.
400 N. 34th St., Suite 100
P.O. Box C-30313
Seattle, WA  98103
(206) 632-8020
September 27, 1991

Bovay Northwest Inc.
4040 Wheaton Way, Suite 202
Bremerton, Washington 98310

Attn: Mr. Michael F. Wnek, P.E.

RE: GEOTECHNICAL REPORT - BANNER ROAD IMPROVEMENTS, KITSAP COUNTY, WASHINGTON

This report presents the results of our geotechnical studies for the proposed improvements to Banner Road. The purpose of our work was to evaluate the actual and impending slope failures along Banner Road located in Southeast Kitsap County, and to provide geotechnical recommendations for remedial work. Our work included drilling four soil borings, conducting laboratory tests and performing engineering analyses to develop design recommendations. The work was done in general accordance with our proposal dated April 12, 1991, and was authorized by Mr. Michael W. Biggs on July 9, 1991. Authorization for additional work was provided by Mr. Michael W. Biggs on August 22, 1991.

SITE AND PROJECT DESCRIPTION

The project site is located near Olalla in Southeast Kitsap County, Washington, as shown on the Vicinity Map, figure 1. The area which was investigated consists of the stretch of Banner Road between Olalla Road in the south and Prospect Point Drive S.E. in the north.

The stretch of Banner Road under investigation is approximately 600 feet long and 17 to 19 feet wide with a shoulder 3 to 4 feet wide on the downslope side. Downslope of the shoulder, the hillside generally slopes down to Puget Sound at angles between 30 and 35 degrees. Upslope of Banner Road, the slopes are near-vertical in most areas. These steep sections are up to 34 feet high. The exposed portions of this near-vertical cut consisted generally of gravelly, silty, fine to medium sand with scattered lenses of silt and clay. Most of the slopes on either side of
Banner Road are covered with assorted shrubs and brush, and fir and maple trees. Areas of seepage were observed along the upslope edge of the road. Scattered bunches of horsetail were observed at near the upslope edge of the road. The first 200 feet of the road, north of its intersection with Olalla Road, slopes up gently towards the north. For the next 400 feet, the road slopes up at an angle of approximately 10 degrees.

Banner Road appears to have been constructed by cutting into the hillside on the upslope side and side-casting the excavated material downslope in order to achieve a full top width for the road. Evidence of slope instability consisting of arcuate cracks extending from the downslope edge of the road to near the center of the road is visible in some areas. Many of these cracks have been filled in the past and show subsequent movement. Based on our conversation with local residents, it is our understanding that about 10 years ago a landslide occurred on the hillside downslope of Banner Road. The head of the landslide scarp reportedly extended to near the center of the road. Further, it is our understanding that the landslide area was filled up to the existing grade with crushed rock/gravel, as part of the remedial measures.

**SUBSURFACE EXPLORATIONS**

The site was explored by means of four soil borings drilled near the downslope shoulder of the road. The boring locations were surveyed by Bovay Northwest, Inc. We understand that a site plan showing the surveyed boring locations is being prepared by Bovay Northwest, Inc. A schematic Site Plan showing the approximate boring locations is presented on Figure 2. Two of the soil borings, designated HB-1 and HB-2, were drilled and sampled by a two-member crew from our office using portable hand-boring equipment using a 40-pound weight falling 18 inches to drive a 1.2-inch O.D. split spoon sampler. The number of blows causing 6-inch increments of penetration of the sampler was recorded and plotted on the boring logs as penetration resistance. The Porter penetration resistance in blows per 6 inches correlates approximately to the standard penetration resistance in blows per foot at values up to about 25. These values indicate the relative density of consistency or the soil.

The other two borings, designated B-1 and B-2, were drilled near the downslope edge of the road by Boretoc, Inc. under subcontract to Shannon and Wilson, Inc. on September 10, 1991. A skid rig using 3¼-inch I.D. hollow-stem auger was used. Standard Penetration tests were performed in the borings at 2.5-foot intervals in these borings. The Standard Penetration test consists of driving a 2-inch O.D. split-spoon sampler a distance of 18 inches into the bottom of the borehole with a 140-pound hammer falling 30 inches. The number of blows required to
drive the sampler each of three 6-inch increments was recorded, and number of blows required to cause the last 12 inches of penetration was termed the Standard Penetration Resistance (N-value). The N-value is an indicator of the relative density or consistency of the soils. Samples obtained from the split spoon sampler were disturbed but were representative of the soils encountered. The boreholes were backfilled immediately upon completion and covered with a cold patch of asphalt.

Samples were field classified by a representative from our firm, sealed in jars, and returned to our laboratory where the classification of each sample was visually checked and the moisture content determined. The results of the penetration tests, moisture contents and soil classifications are summarized on the boring logs, Figures 3 through 6.

SITE CONDITIONS

The geologic map of the Kitsap Peninsula (State of Washington, Department of Conservation, Division of Water Resources, 1962) indicates that the site is underlain by glacial till and advance outwash deposits. Both these geologic units have been preconsolidated by the weight of several thousand feet of glacial ice and are generally very dense. The advance outwash exposed in this road cut generally consists of medium dense to very dense, clean to silty, sand, sandy gravel and gravelly sand, with lenses of silt and clay. Glacial till primarily consists of a mixture of gravel, sand, silt and clay.

Subsurface conditions at the site are illustrated by the profiles shown on Figures 7 and 8. The results of our subsurface exploration indicate that the site is generally underlain by 10 to 12 feet of fill consisting of very loose to medium dense, silty, fine to medium sand with scattered fine gravel. The fill is underlain by advance outwash deposits consisting of medium dense to very dense, gravelly, silty sand and sandy gravel.

In boring B-1, approximately 7.5 feet of rock/gravel was encountered between the fill and advance outwash deposits. It appears that this layer was deposited as part of the remedial measures for a landslide which reportedly occurred about 10 years ago.

During our explorations, soils were generally moist. Traces of wet sand were encountered just above the advance outwash deposits, indicative of perched water conditions. Some seepage was observed near the upslope edge opposite borings HB-2 and B-1. Scattered horsetail was observed
along the upslope edge of the road between borings HB-1 and HB-2, and dried horsetail was observed along the downslope shoulder near boring HB-1.

CONCLUSIONS AND RECOMMENDATIONS

The results of our subsurface explorations and studies indicate that the native soils at the site consist primarily of densely compacted, glacially overridden deposits. These soils have high shear strengths and low compressibilities. In our opinion, instability of the hillside downslope of Banner Road, which has resulted in cracking along sections of Banner Road has occurred in the fill soils which overlie the native advance outwash deposits. These fill soils, which appear to have been placed when Banner Road was being constructed, are very loose to medium dense, and are subject to creep and sloughing on steep slopes, especially when saturated.

In our opinion, the creep and sloughing of the fill soil is being caused by steepening of the slope due to erosional action of tides at the toe of the slope. Erosion of the slope material by tides cuts into the toe of the slope making it unstable. The slope instability appears to have been exacerbated by saturation of the fill soils due to groundwater seepage. Saturation of the slope soils has a twofold deleterious effect on the slope stability: (a) it decreases the 'effective stress' of the soil, the mechanism by which soil derives its strength, and (b) it increases the weight of the soil, thereby increasing the driving force for the sliding soil mass.

Improving the Stability of Slopes Below Banner Road

In our opinion, remedial measures to improve the stability of the slope below Banner Road should consist of the following:

(1) Constructing a seawall to protect the toe of the slope from further erosion by tides. Backfilling the seawall to buttress the toe and flatten the slope behind the wall.

(2) Installing a trench subdrain along the upslope edge of the road to protect against the buildup of hydrostatic pressure in the fill underlying the road.

In our opinion, the above remedial measures will improve the long term stability of the slope. However, a small amount of additional settlement and creep of the fill soils should be anticipated after completion of the recommended remedial work before it adjusts to the new slope.
Recommendations for design of seawall and trench subdrain are presented in subsequent sections of this report.

**Increasing the Stability of Slopes Above Banner Road**

In our opinion, sloughing of the loose, surficial soils on the steep slopes above Banner Road could be reduced by one or a combination of the following: flattening the slopes, providing a drained shotcrete facing for the steep portions of the slopes, or retaining the slopes with walls. Low retaining walls could also be constructed along the inside shoulder of the road to provide a catchment area and prevent debris from sloughing onto the road.

From an engineering viewpoint, an effective option would be to flatten the slopes above Banner Road. In general, slopes flatter than about 2 Horizontal to 1 Vertical would not be susceptible to sloughing and creep. However, in some areas where existing residences are located on top of the slope, it might not be feasible to flatten the slope.

Facing for the slopes could be provided by shotcrete, rockeries or ecology block walls. Shotcrete can be designed for the range in slope heights encountered at this site and would involve limited excavation. Recommendations for shotcrete facing are presented in a subsequent section of this report. Rockeries are generally used for protection of stable cut slopes with heights limited to about 10 feet. Rockeries should be constructed in accordance with the Typical Rockery Detail provided in Figure 11.

Retaining walls such as reinforced concrete cantilevered walls, crib walls, gabions, or reinforced-soil walls could be used to retain the steep slopes above Banner Road. These walls can be constructed to various heights up to about 20 feet; however, the width of the base of these walls is generally 50 to 80 percent of the wall height. Installation of such a wall could require substantial excavation into the hillside.

Ecology blocks may be used to provide low gravity retaining walls or for protection of stable cut slopes. Ecology blocks consist of $2 \times 2 \times 6$ foot solid rectangular concrete blocks. They are cast from excess concrete at concrete batch plants and are relatively inexpensive. Because of their rectangular shape, they can be stacked in a variety of ways, space permitting, to form gravity retaining walls. Typical ecology block walls are presented on Figures 9 and 10. Ecology block walls with blocks stacked as shown in Figure 9 (parallel to the slope), should not exceed
about 7 feet. Where blocks can be placed perpendicular to the slope face as shown in Figure 10, ecology block walls should not exceed about 14 feet in height.

Depending on the amount of space available, it may be possible to control sloughing of the soils on the steep slopes by constructing flat bottom ditches and/or installing barriers to contain slough material. Ecology blocks could be used for such barriers. Periodic removal of debris from the ditch or behind the barriers would be required.

Based on our studies of the slopes along the roadway, we recommend that the slopes be flattened to 2 horizontal to 1 vertical wherever possible. Where flattening the slope is not feasible, we recommend that the slopes be retained with Ecology block walls stacked in accordance with the recommendations presented on Figures 9 and 10. A combination of flattening and ecology blocks should be used to the extent possible.

The following sections present additional recommendations for the design and implementation of the slope stabilization measures discussed above.

Sea Wall Design

Sea walls should be designed in accordance with the Typical Sea Wall Design provided in Figure 13. A Sea wall consisting of large quarry rock could be backfilled to a maximum slope of 1.5H to 1V to protect the toe of the existing slope from erosion. The minimum recommended elevation for the top of the sea wall is about 21 feet (MLLW, U.S.C. & G.S. Datum). This elevation is approximately 6.5 feet above the highest observed tide. The backfill behind the wall should consist of 1¼-inch minus crushed rock which will provide a filter to prevent the loss of fine grained soils throughout the backfill. The backfill should be placed in lifts and compacted with construction equipment to a dense and unyielding condition. Immediately behind the wall, the backfill should be compacted with a hand-operated vibratory compactor.

Trench Subdrain

Trench subdrain should consist of a 6-inch (minimum) diameter slotted plastic pipe embedded at the bottom of a sand and gravel filled trench, as shown on Figure 14. The depth of this trench is anticipated to be about 6 feet; however, the actual depth should be determined in the field during construction. Near the intersection of Banner Road with Olalla Road, the slotted pipe should be converted to a tightline and a dam of clayey soil or concrete should be placed in the
trench to force water into the tightline. The tightline should be connected to a suitable discharge point such as a storm drain system.

Retaining Structures

Retaining structures should be founded in dense to very dense native soils or on compacted structural fill placed on these soils. Depths to competent bearing soils are estimated to be 10 to 15 feet below the downslope shoulder of the road and within 2 or 3 feet of the surface along the upslope shoulder in the slide areas. In our opinion, foundations for retaining walls supported in the dense to very dense native soils could be designed for an allowable bearing pressure of 4,000 pounds per square foot (psf). Foundations bearing in structural fill placed over the dense to very dense native soil could also be designed for 4,000 psf allowable bearing pressures.

Foundation subgrades should be evaluated during construction by a geotechnical engineer or his/her representative to confirm the presence of competent bearing soil, and to determine that all soft or loosened, disturbed soils and all existing fill have been removed.

Retaining structures should be designed for an equivalent fluid pressure of 35 pcf, plus one pound per cubic foot for each degree of upward inclination of the backslope above the wall. This pressure assumes that proper drainage is provided behind the walls so that no buildup of hydrostatic pressure occurs. The above value does not account for surcharge loads near the walls, such as heavy construction machinery or traffic loads. A lateral pressure due to surcharges should be added to the recommended earth pressure, where appropriate.

Lateral forces would be resisted by passive earth pressure against the buried portions of walls and by friction against the bottom. In our opinion, passive earth pressures in backfill could be estimated using an equivalent fluid pressure of 280 pcf above the groundwater level (above footing subdrain elevations) and 140 pcf below the water or subdrain levels. This passive pressure assumes a compacted granular structural fill which extends horizontally beyond the footing a distance of at least twice the depth of the passive zone below the ground surface. We recommend that a coefficient of friction of 0.5 be used between cast-in-place concrete and soil. An appropriate factor-of-safety should be used to calculate the resistance to sliding due to passive earth pressure against foundations and friction at the base of footings.
Retaining wall backfill should consist of clean, well-graded 1-¼-inch minus crushed rock or sand and gravel with less than 20 percent passing the No. 100 sieve, based upon wet sieving. All backfill should be compacted to at least 92 percent of its modified proctor maximum dry density (ASTM-D 1557-70, Method C or D).

A subdrain system consisting of a 4-inch-diameter slotted plastic pipe embedded in the crushed rock should be installed along the upslope side of footings for retaining walls. Water collected in this pipe should flow via tightline to a suitable discharge point away from the slope.

**Shotcrete**

Shotcrete is concrete consisting of cement mortar with aggregate that is sprayed onto the surface to be treated. When used as facing for soil surfaces, the shotcrete should be reinforced with welded-wire mesh which is structurally connected to grouted anchor rods, as shown in Figure 12. The shotcrete can be colored, if desired.

At this site, anchor rods consisting of #4 steel reinforcing bars should be installed on three-foot centers. They should be grouted into drilled holes extending a minimum 4 feet into competent, dense native soils. Drainage behind the shotcrete should be provided by a composite drainage mat. The permeable side of the drainage mat should be placed against the slope and the impermeable side placed outward. We recommend that the design details be prepared by a contractor experienced in shotcrete work and that the design be reviewed by Shannon & Wilson, Inc.

**Excavations**

For safe working conditions and prevention of ground loss, excavation slopes should be the responsibility of the Contractor since he will be at the job site to observe and control the work. All current and applicable safety regulations regarding excavations slopes and shoring should be followed.

For planning purposes we recommend that temporary unsupported open cut slopes in loose soils be no steeper than 1.0 Vertical to 1.25 Horizontal (1V to 1.25). Open cuts in glacially consolidated soils could be steeper, depending on conditions encountered. We recommend that all exposed cut slopes be protected with a waterproof covering during periods of wet weather to reduce sloughing and erosion.
Unless included as a surcharge load on a shoring system, excavated material, or stockpiles of construction materials or equipment, should be placed no closer than a distance equal to the depth of the excavation from the top edge of the excavation.

The Contractor should be responsible for the control of ground and surface water within the contract limits. In this regard sloping, slope protection, ditching, sumps, dewatering, and other measures should be employed as necessary to permit proper completion of work.

**Fill Placement and Compaction**

All soft or loose soils and all soils containing organics should be removed from areas to receive structural fill prior to fill placement. All fill placed beneath the roadway should consist of structural fill.

Structural fill should consist of relatively well graded sand or sand and gravel having a maximum particle size of about 3 inches. It should not contain more than about 10 percent fines (material passing the No. 200 mesh sieve) by weight, based on the minus \( \frac{3}{4} \) inch soil fraction. All fill should be placed in horizontal lifts and compacted to a dense and unyielding surface and at least 95 percent of its modified Proctor maximum density. (ASTM: D1557-70, Method C or D). The thickness of loose lifts should not exceed 8 inches for heavy equipment compactors and 4 inches for hand operated compactors. Depending upon its composition, up to three feet of fill may be satisfactorily compacted using a large hoepac compactor.

Most of the on site native soil should be suitable for use as structural fill providing its moisture content is sufficiently close to the optimum. Some of the native site soils contain sufficient quantities of silt to create a cohesive mixture when wet. As a result these soils may become muddy and difficult to handle when wet. At the time our explorations were made (in August and September, 1991) the moisture content of the in-place soils was generally at or below their optimum. Some moisture conditioning (either wetting or drying) may be needed if these soils are to be used as structural fill. They may not be suitable for use as structural fill in wet weather.
Erosion Control

The loose sands at the ground surface are susceptible to erosion if left unprotected. Therefore, we recommend that as much of the site as possible be maintained in natural existing vegetation to reduce the potential for erosion. Silt fences and/or bales of straw should be strategically placed on the site to control erosion during construction. Planting and mulching of all disturbed sloping ground should be completed as soon as possible after construction is completed. If permanent landscaping is not established by this time, temporary erosion control measures should be implemented. In this regard, the advice of a landscape architect/contractor should be obtained.

WET WEATHER EARTHWORK

If fill is to be placed in wet weather or under wet conditions when control of soil moisture content is not possible, the fill should contain no more than 5 percent material passing the No. 200 mesh sieve, by weight, based on the minus ¾ inch fraction. In addition:

a. The ground surface in the construction area should be sloped and sealed with a smooth drum roller to promote the rapid runoff of precipitation and to prevent ponding of water;

b. Earthwork should be accomplished in small sections and carried through to completion to minimize exposure to wet weather. If there is to be traffic over the exposed subgrade, the subgrade should be protected with a compacted layer of clean sand and gravel or crushed rock. The size or type of equipment may have to be limited to prevent soil disturbance;

c. No soil should be left uncompacted so it can soak up water. Soils which become too wet for compaction should be removed and replaced with clean granular material; and,

d. Excavation and placement of fill should be observed on a full time basis by a person experienced in wet weather earthwork to determine that all unsuitable materials are removed and suitable compaction and site drainage is achieved.

We recommend that these recommendations for wet weather earthwork be included in the contract specifications.
LIMITATIONS

The conclusions and recommendations presented in this report are based on site conditions as they presently exist and assume that the explorations are representative of the subsurface conditions throughout the site, i.e., the subsurface conditions are not significantly different from those encountered in the explorations. If during construction, subsurface conditions different from those encountered in the explorations are observed or appear to be present, we should be advised at once so that we can review those conditions and reconsider our recommendations were necessary. If there is a substantial lapse of time between submission of our report and the start of work at the site, or if conditions have changed due to natural causes or construction operations at or near the site, it is recommended that this report be reviewed to determine the applicability of the conclusions and recommendations considering the changed conditions and time lapse.

The scope of our services did not include an environmental assessment or evaluation regarding the presence or absence of wetlands or hazardous or toxic materials in the soil, surface water, groundwater, or air, on or around or below this site.

We recommend we be retained to review those portions of the plans and specifications which pertain to earthwork and drainage to determine that they are in accordance with our recommendations. We also suggest a meeting with you and the contractor to discuss earthwork and drainage requirements. We also recommend we be retained to monitor the geotechnical aspects of construction, particularly, the excavations, fill placement and compaction, in-place soil densification, shotcrete application, and installation of drains. This monitoring would allow us to verify the subsurface conditions as they are exposed during construction and to determine that the work is accomplished in accordance with our recommendations.

This report was prepared for the use of the owner and engineer in the design of the structures. It should be made available to prospective contractors or the contractor for information on factual data only and not as a warranty of subsurface conditions, such as those interpreted from the boring logs and discussions of subsurface included in this report.

Unanticipated conditions are commonly encountered and cannot be fully determined by merely taking soil samples or making explorations. Such unexpected conditions frequently require that additional expenditures be made to achieve a properly constructed project. Some contingency fund is recommended to accommodate such potential extra costs.
The recommendations given in this report are intended to suitable increase the factor-of-safety against future instability for the area damaged by earth movement. In our opinion, the risk of hillside instability damaging the road will be significantly reduced, if the recommended remedial measures are properly completed. Nonetheless, there is present on all hillsides, such as the one here, some risk of future hillside instability, particularly for areas outside of the repair area. Such instability could occur due to future water leaks, uncontrolled drainage, unwise development in adjacent areas, or other actions or events on the slope which may cause sliding.

We appreciated this opportunity to be of service. We look forward to working with you on the construction phase of this project.

Sincerely,

SHANNON & WILSON, INC.

[Signature]
Sandeep Puri
Engineer

[Stamp]
Ralph N. Boirum, P.E.
Senior Associate

SP:RNB:TEK/dk

Enclosures: Figures 1 through 14
Important Information About Your Geotechnical Engineering Report
NOTE
LEGEND

B-1 ○ Boring Designation and Approximate Location

HB-1 ● Hand Boring Designation and Approximate Location

A ↑ Subsurface Profile Designation and Approximate Location

Banner Road Improvements
Kitsap County, Washington

SITE PLAN
September 1991 W-5813-02

SHANNON & WILSON, INC.
Geotechnical Consultants

FIG. 2
**SOIL DESCRIPTION**

<table>
<thead>
<tr>
<th>Depth, Ft.</th>
<th>Ground Water Depth, Ft.</th>
<th>Porter Penetration Resistance (40 lb. weight, 18&quot; drop)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>▲ Blows per 6&quot;</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

**Surface Elevation:**

Very loose to loose, brown, silty, fine SAND; scattered fine to medium gravel; dry to moist

**BOTTOM OF BORING COMPLETED 8-7-91**

**NOTE**

Boring abandoned at 7.5 feet because augering past gravel was not possible.

**LEGEND**

- Porter split spoon sample
- Thin-wall tube sample
- Sample not recovered
- Impervious seal
- Water level
- Piezometer tip
- Sample pushed
- Liquid limit
- Natural water content
- Plastic limit

The stratification lines represent the approx. boundaries between soil types, and the transition may be gradual.

**LOG OF BORING HB-1**

September 1991  W-5813-02

Banner Road Improvements Kitsap County, Washington

SHANNON & WILSON, INC.
Geotechnical Consultants

FIG. 3
SOIL DESCRIPTION

Surface Elevation:

<table>
<thead>
<tr>
<th>Depth, Fl.</th>
<th>Samples</th>
<th>Ground Water</th>
<th>Porter Penetration Resistance (40 lb. weight, 18&quot; drop)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5</td>
<td>0</td>
<td>0</td>
<td>Blows per 6&quot;</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Loose, brown, silty, fine SAND; scattered fine gravel; dry to moist

Loose, brown, slightly silty to silty, fine to medium SAND; moist

Medium dense, brown, slightly silty to silty, fine to medium SAND; scattered fine gravel; moist

BOTTOM OF BORING
COMPLETED 08-07-91

NOTE
Boring abandoned at 13.5 feet because augering past gravel was not possible.

LEGEND

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>Porter split spoon sample</td>
</tr>
<tr>
<td>II</td>
<td>Thin-wall tube sample</td>
</tr>
<tr>
<td>•</td>
<td>Sample not recovered</td>
</tr>
<tr>
<td></td>
<td>Impervious seal</td>
</tr>
<tr>
<td></td>
<td>Water level</td>
</tr>
<tr>
<td></td>
<td>Piezometer tip</td>
</tr>
<tr>
<td></td>
<td>Sample pushed</td>
</tr>
<tr>
<td></td>
<td>Liquid limit</td>
</tr>
<tr>
<td></td>
<td>Natural water content</td>
</tr>
<tr>
<td></td>
<td>Plastic limit</td>
</tr>
</tbody>
</table>

Atterberg limits:
The stratification lines represent the approx. boundaries between soil types, and the transition may be gradual.

Banner Road Improvements
Kitsap County, Washington

LOG OF BORING HB-2
September 1991
W-5813-02
SHANNON & WILSON, INC. Geotechnical Consultants
FIG. 4
SOIL DESCRIPTION

Surface Elevation:

Loose to medium dense, brown, silty, fine to medium SAND; scattered fine gravel; moist

Medium dense, brown, gravelly, silty, fine to medium SAND; moist

Dense to very dense, brown, silty, sandy GRAVEL; trace of gray, clean, fine to medium sand; moist

Dense to very dense, brown, gravelly, silty, fine to medium SAND; occasional reddish brown oxide staining; moist

BOTTOM OF BORING COMPLETED 09-10-91

NOTE
Top 6" is pavement section.

LEGEND

Porter split spoon sample
Thin-wall tube sample
Sample not recovered
Atterberg limits:

- Liquid limit
Natural water content
Plastic limit

Impervious seal
Water level
Piezometer tip
Sample pushed

Porter Penetration Resistance (140 lb. weight, 30° drop)
△ Blows per foot

BOTTOM OF BORING
COMPLETED 09-10-91

NOTE
Top 6" is pavement section.

LOG OF BORING B-1
September 1991

SHANNON & WILSON, INC.
Geotechnical Consultants
SOIL DESCRIPTION

Surface Elevation:

0

Loose, brown, silty, fine to medium SAND; scattered fine gravel; moist

10

Medium dense, light brown, slightly silty, fine to medium SAND; occasional silt lenses; moist to wet

21.5

Dense to very dense, grayish brown, slightly silty to silty, fine to medium SAND; scattered gravel; gravely below 20 feet; moist

BOTTOM OF BORING
COMPLETED 09-10-91

NOTE
Top 6" pavement section.

LEGEND

I  Porter split spoon sample
II Thin-wall tube sample
• Sample not recovered

Atterberg limits:
- Liquid limit
- Natural water content
- Plastic limit

Impervious seal
Water level
Piezometer tip
Sample pushed

Standard Penetration Resistance
(140 lb. weight, 30" drop)
△ Blows per foot

0 20 40 60

0 5 10 15 20 25 30 35 40 45 50 50'1'

LOG OF BORING B-2
September 1991 W-5813-02

Banner Road Improvements
Kitsap County, Washington

SHANNON & WILSON, INC.
Geotechnical Consultants

FIG. 6
1. This profile is generalized from materials encountered in the borings. Variations between the profile and actual conditions may exist.

2. Approximate ground surface estimated by rough measurements with hand level and rod.

3. Elevation datum assumed as 0 feet on the water surface at 11:00 a.m. on B-7-91.

LEGEND

B-1/HB-2 — Boring Designation and Location

? — Approximate Geologic Contact

Bottom of Boring

HB-2 (Elev. 28.6) B-1

Loose (some medium dense), sily, fine to medium SAND; scattered fine gravel

Medium dense, gravelly, silty, fine to medium SAND

Dense to very dense, sandy GRAVEL

Dense to very dense, gravelly, silty SAND

Submerged by the Tide

Existing Ground Surface

Estimated Failure Surface

NOTES

Scale in Feet

0 10 20

Banner Road Improvements
Kitsap County, Washington

GENERALIZED SUBSURFACE PROFILE A-A'

September 1991

SHANNON & WILSON, INC.
Geotechnical Consultants

W-5813-02

FIG. 7
1. This profile is generalized from materials encountered in the borings. Variations between the profile and actual conditions may exist.

2. Approximate ground surface estimated by rough measurements with hand level and rod.

3. Elevation datum assumed as 0 feet on the water surface at 11:00 a.m. on 8-7-91.
2' x 2' x 6' Solid Concrete Blocks (Ecology Blocks)
4 blocks maximum height

1 Vertical to 2 Horizontal (maximum) Backslope Angle

Stable Excavation Slope in Dense Native Soil (Contractor's responsibility)

BACKFILL
Clean, well-graded, crushed rock. 1-1/4" maximum size. Less than 2% fines (passing #100 sieve). Fines shall be non-plastic.
Compact in 4" lifts to at least 92% of Modified Proctor maximum dry density (ASTM D-1557). Backfill and block placement should be built up together.

4" Diameter Slotted Plastic Pipe, bedded in washed 3/8" pea gravel (6" cover around pipe), sloped to drain and connected by tightline to storm drain outfall. No fabric around pipe.

All loose soil at block foundation should be excavated and replaced with compacted backfill as described above. The excavation shall be kept free of water. The prepared block foundation shall be evaluated by a soils engineer prior to placement of blocks. Backfill should be placed and compacted as the blocks are placed.

Not Drawn to Scale

Banner Road Improvements
Kitsap County, Washington

TYPICAL SECTION SHORT ECOLOGY BLOCK WALL
September 1991 W-5813-02
SHANNON & WILSON, INC.
Geotechnical Consultants FIG. 9
NOTES

1. All loose soil at block foundation should be excavated and replaced with compacted backfill as described above. The excavation shall be kept free of water. The prepared foundation subgrade shall be evaluated by a soils engineer prior to placement of blocks.

2. Three layers of block 'B' may be used. 'A' blocks may be stacked 3 high (4 high if the backslope is horizontal). Backfill should be placed and compacted as the blocks are placed.
8" Compacted Native Soil (Impervious Surface Layer)

Max. Slope
3

Stable Excavation Slope (Contractor's Responsibility)

Openings Chinked with Quarry Spalls

Backfill

Clean, well-graded sand & gravel or crushed rock, 1-1/4" max. size, less than 2% fines (passing #100 sieve). Fines shall be non-plastic.

Compact in 4" lifts to at least 92% of Modified Proctor maximum dry density (ASTM D-1557-70). Backfill and rock placement should be built up together.

4" Diameter Slotted Plastic Pipe, bedded in washed 3/8" pea gravel (6" cover around pipe), sloped to drain and connected by tightline to storm drain outfall. No fabric around pipe.

All loose to medium dense soil at rockery foundation should be excavated and replaced with compacted backfill as described above. The excavation shall be kept free of water. The prepared rockery foundation shall be evaluated by a soils engineer prior to placement of rock.

Not to Scale

MINIMUM WEIGHT OF ROCK

Portion of wall below 6 ft., 2400 lb. ("6-man") rock. Upper 6 ft. of wall, 1600 lb. ("4-man") rock.

Banner Road Improvements
Kitsap County, Washington

TYPICAL ROCKERY DETAIL

September 1991

SHANNON & WILSON, INC.
Geotechnical Consultants

FIG. 11

W-5813-02
Detail

Anchor Rods Inserted into Grout-Filled Holes; Typically Spaced on a 3 to 4 Foot Grid (Provide corrosion protection near face)

TYPICAL SECTION

Not to Scale

Shotcrete Treatment of Face (See detail)

FIG. 12
NOTES

1. Base rock of sea wall should consist of durable 4- to 8-ton quarry rock with a minimum hardness of 5.

2. The crushed rock backfill should extend at least 5 feet back from the back side of the sea wall.

3. All fill should be placed in lifts and systematically compacted to a dense and unyielding condition.

4. The top of the sea wall should be at or above elevation 21 feet (MLLW, U.S.C. & G.S. Datum).
Impervious Soil or Subbase and Pavement, 6 Inches

Trench Excavation

Compacted Drainage Sand and Gravel (See Specifications Below)

Subdrain Pipe

No. 10 Mesh Sieve to 3/8-in. Pea Gravel at Least 6-in. Thick Around Pipe

WITHOUT FILTER FABRIC

Not to Scale

SPECIFICATIONS FOR DRAINAGE SAND & GRAVEL

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>% Passing by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 1/2</td>
<td>100</td>
</tr>
<tr>
<td>3/4</td>
<td>90 to 100</td>
</tr>
<tr>
<td>1/4</td>
<td>75 to 100</td>
</tr>
<tr>
<td>No. 8</td>
<td>65 to 92</td>
</tr>
<tr>
<td>No. 30</td>
<td>20 to 65</td>
</tr>
<tr>
<td>No. 50</td>
<td>5 to 20</td>
</tr>
<tr>
<td>No. 100</td>
<td>0 to 2</td>
</tr>
</tbody>
</table>

(by wet sieving) (non-plastic lines)

NOTE

Dimensions shown in diagram are minimum recommended thicknesses.

SUBDRAIN PIPE

Perforated or slotted pipe; tight joints; sloped to drain; provide clean-outs; min. dia.: 4 inches.

Perforated pipe holes (1/8-in. to 1/4-in. dia.) to be in lower half of pipe with lower quarter segment unperforated for water flow.

Slotted pipe to have 1/8-in. max. width slots.

Beneath structures or pavements, drain backfill should be compacted to at least 95% of its modified proctor max. density.

Banner Road Improvements
Kitsap County, Washington

TYPICAL SUBDRAIN INSTALLATION

September 1991 W-5813-02

SHANNON & WILSON, INC.
Geotechnical Consultants FIG. 14