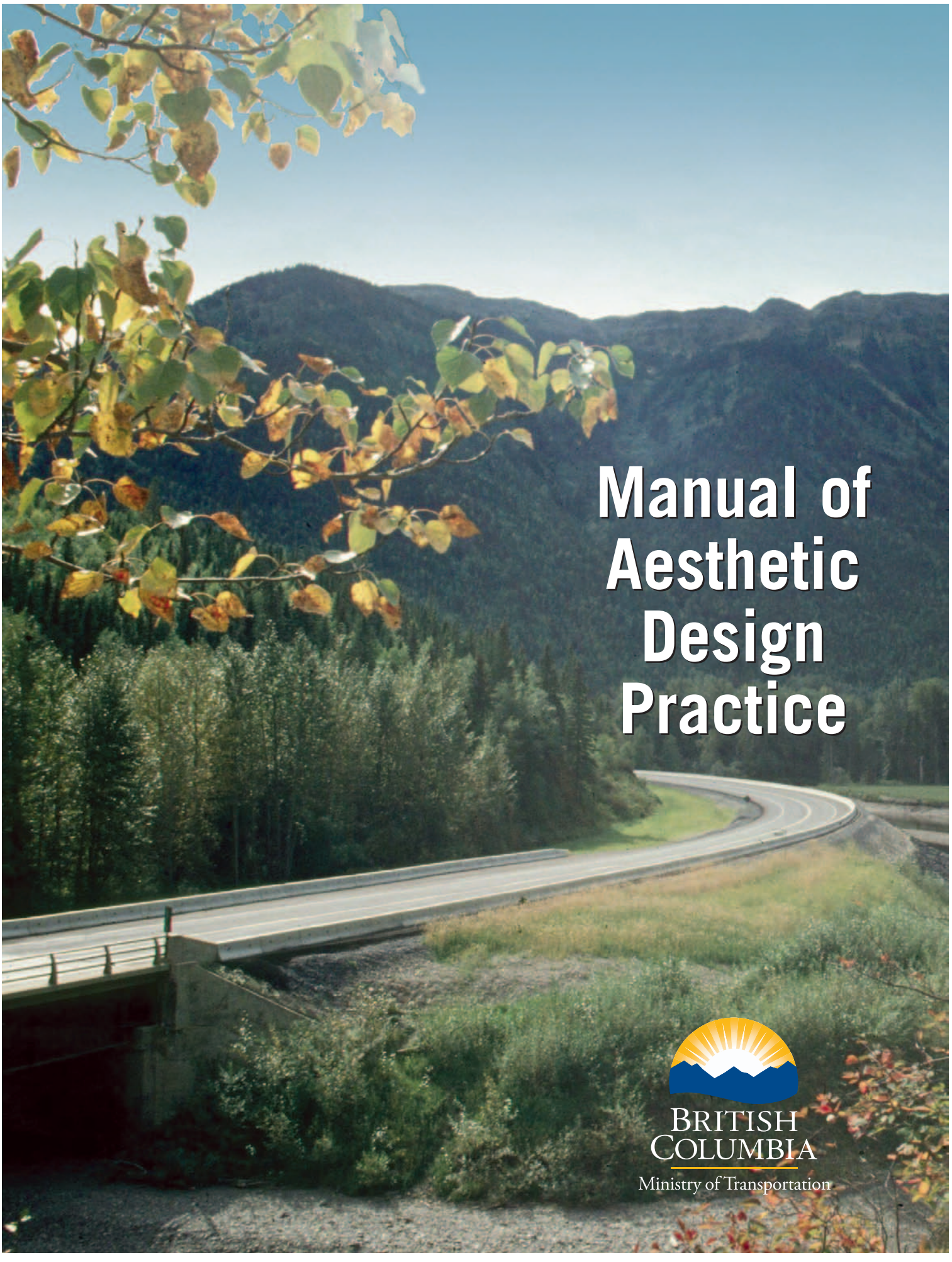

Manual of Aesthetic Design Practice

BRITISH COLUMBIA
Ministry of Transportation

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Earthworks

Earthworks

Introduction

The objective of earthwork as it relates to aesthetic highway development will be to ensure that all areas beyond the edge of the pavement relate seamlessly to the surrounding terrain. To achieve this objective engineering solutions which are safe and functional must also be designed to blend with adjacent landscapes. Where structures are incorporated as part of highway design, earthworks will provide the transition between the structural element and the surrounding terrain.

The co-ordination of engineers, designers and consultants from the initial stages of corridor and alignment selection through into preparatory work to detail design is essential to identify and incorporate responsive earthwork plans.

Specific earthwork circumstances addressed in this section include the following:

- **Borrow pits, settling ponds, and basins** which should be graded to blend with the adjacent landscape character.
- **Blast cuts**, particularly where they form part of the skyline.
- **Ditches** which can be graded to integrate with the adjacent terrain.
- **Uphill and downhill slopes** where grading issues can be considerable in areas of steep terrain.
- **Medians** which can be developed to include borrow pits and bermed areas and become a source of visual interest.
- **Culverts** which should be detailed to create a minimum visual impact.
- **Berms** which should be well integrated with adjacent topography.
- **Avalanche barriers and retaining structures** should be graded to blend into the surrounding landscape character.
- **Bridges, overpasses, and interchanges** should be developed to respond to aesthetic objectives and tie into the earth naturally at their foundations.
- **Roadside facilities** require specific attention to earthwork development as a result of the close scrutiny they receive from pedestrian traffic.

Recommended Practices

The following pages outline recommended practices concerning the aesthetics of earthworks associated with highways in B.C., as summarized below:

1.0 Decide routes to, and location of borrow pits, storm run-off retention ponds and silt settling basins before clearing commences.

2.0 Analyze soils, their potential for and means to mitigate erosion.

3.0 Reflect the natural conditions of the adjacent terrain.

4.0 Apply these standard guidelines for earthworks to all areas impacted by roadway development.

Note: Construction will not be considered complete until site revegetation has been accomplished on all earthworks.

1.0 Location of Borrow Pits, Surplus Disposal, Ponds, and Basins.

Decide routes to, and location of borrow pits, surplus disposal sites, storm run-off retention ponds and silt settling basins before clearing commences.

.1 Integrate borrow pit, and surplus disposal site location with highway design.

- Identify features within right of way which may be used as fill in lieu of borrow pits.
  - remove landforms which obscure operational safe sight distances (eg. remove roadside grade on inside curve, which obscures passing sight distance; maximum 600mm height above pavement elevation).
  - eliminate peculiar or view-obstructing remnants of cuts.
- Limit use of ditch/swale area for borrowing of fill.*

*refer to EARTHWORKS (Ditches) for design details

**refer to ALIGNMENT (Drivers Interest and Experience) for applicable locations.

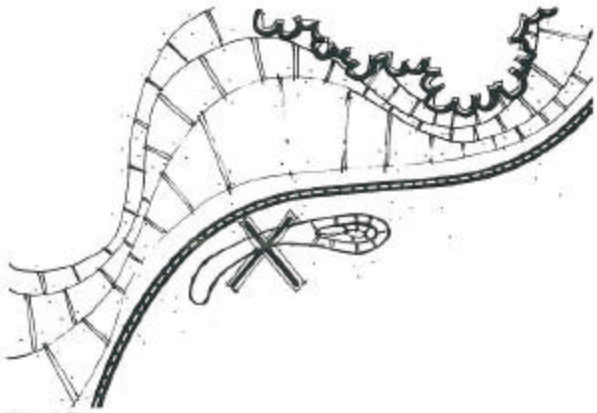

Figure F-1
Remove landforms as required for safe sight distance.

- Locate borrow pits to be adapted to other uses.*
  - simulate naturally occurring depression within median or "lay backs" in right of way cut to provide topographical relief.
  - create depressions for use as sloughs or ponds for potential wildlife and aesthetic value.
  - allocate for slash and scree disposal.
  - fill and rehabilitate for roadside facilities.
  - convert to settling basin.

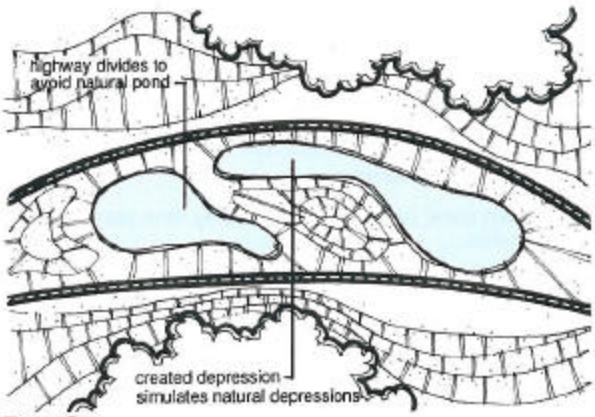

Figure F-2
Borrow areas within the right of way can be shaped to resemble naturally occurring topography.

Figure F-3
This substantial fill disposal site is largely concealed from the highway because of the vegetation left at the roadway edge.

- Minimize the visibility of those borrow pits and disposal sites to remain after completion of highway.
  - separate by minimum 20m wide vegetative screen exclusive of right of way clearing requirement.
  - intersect access road with the primary road at a 90 degree angle. The tangent of the access road at the intersection should be no longer than 15m with the curve leading into this tangent of no less than 15 degrees.**

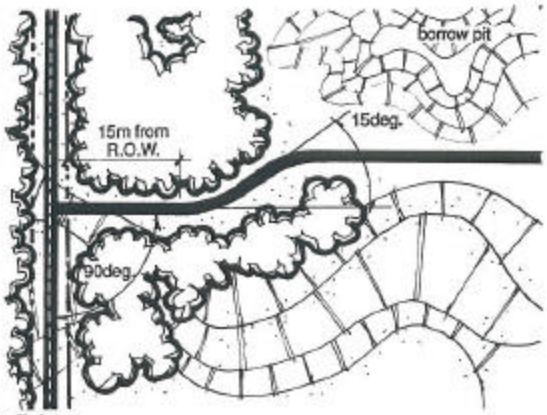

Figure F-4
Borrow pits and access routes to pits can be screened by vegetation. Locate borrow pit and access road to leave effective vegetation buffer.

Figure F-5
This permanent quarry site would have been better located further from the roadway edge and concealed from view by a vegetated buffer.

.2 Integrate retention pond and settling basin location with highway design.**

- Integrate permanent erosion control measures (eg. storm run-off retention ponds and silt settling basins and their channels) with the natural drainage system.
  - identify naturally occurring depressions within and adjacent to right-of-way to be cleared and/or reshaped.***
- Rehabilitate all areas within view of completed highway used for temporary erosion control measures.***

Figure F-6
This retention pond located within the right of way could have been designed to create a more naturalistic shape.

*refer to ALIGNMENT (Drivers Interest and Experience) for applicable locations.

**refer to VISUAL RESOURCE ANALYSIS for environmental constraints

***refer to CLEARING AND GRUBBING for space requirements and implications to existing vegetation.

***refer to EARTHWORKS and REVEGETATION for integration with adjacent site conditions and erosion control.

2.0 Site Preparation

Assess soils to determine their potential for subsequent revegetation.

.1 Retain topsoil for future use in revegetation.

- Strip and store all usable topsoil. Sub-soil horizons where high organic content exists may also be stripped and stored if required. Where abnormally deep topsoil exists store only the amount required for the project.
- Locate storage areas and haul routes to within known clearance areas.
  - store on well drained area of right of way.
  - store in linear mounds 3m wide to a height of 1.3m, with 3:1 sideslopes. Wider piles should be limited to a maximum height of 1m.

Figure F-7
Stockpile topsoil within the limits of cleared areas in well drained areas.

.2 Conserve the use of retained topsoil for areas of high visibility and areas to be revegetated with trees and shrubs.

Figure F-8
Topsoil samples should be collected from the site and tested to determine nutrient content, texture, and structure.

Figure F-9
Topsoil should be retained for areas of high visibility, which are most likely to be revegetated with trees or shrubs, such as interchanges.

3.0 Integration with Adjacent Topography

Reflect the natural conditions of the adjacent terrain.

.1 Avoid a constant width of grading.

- Vary the angle of slope over the length of the slope.
  - warp the slope to acknowledge drainage channels or "lay backs". Slopes will reflect angle of repose of soil.
  - create "lay backs", where cut slope exceeds 5 seconds in length at highway design speed. The warp, width of mouth, and length should be typical of adjacent natural terrain.

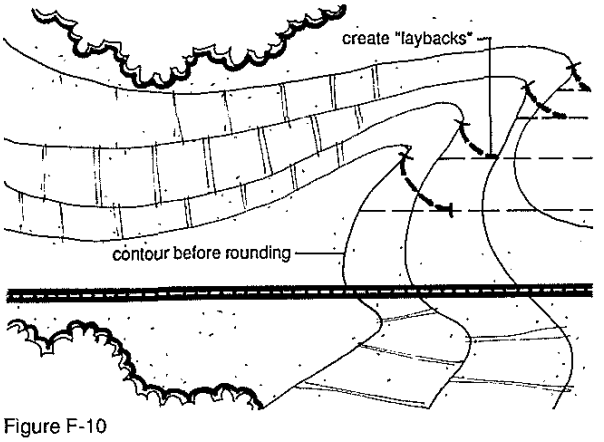

Figure F-10
At natural drainage channels, blend the slope to create 'lay-backs'.

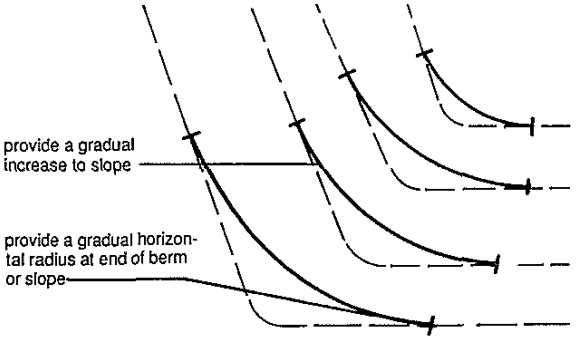

Figure F-11
Typical feathering of the ends of a slope.

- Feather the ends of the slope.
  - provide a transition from the maximum angle of slope to blend in with the adjacent site, with warp typical of adjacent natural terrain.
- Round the toe and top of slope.
  - provide a minimum radius of 3m at the top of slope to blend the midpoint angle of slope to the adjacent undisturbed site.
  - provide a minimum radius of 3m at the toe of the slope to blend the midpoint angle of slope to the adjacent undisturbed site.

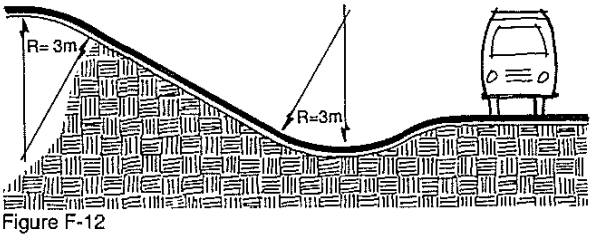

Figure F-12
Typical rounding at top and bottom of slope.

.2 Ensure that the length of slope matches the scale of the angle of slope typical to the adjacent terrain.

- Avoid the appearance of unnatural steepness on short slope lengths.
  - for cut or fill slopes of less than 1.5m ht. use a maximum slope of 4:1.
  - for cut or fill slopes between 1.5 - 3.0m ht. use a maximum slope of 3:1.
- For slopes of cut and fill exceeding 3.0m ht. consider all slopes visible within the viewshed.*
  - use maximum 3:1 slope on slopes of erodible soils or areas to be mowed.
  - where feasible do not exceed the slope of dominant background hills and mountains in view.

Figure F-13
Avoid the appearance of unnatural steepness on short slope lengths.

.3 Retain and incorporate naturally occurring landforms within the cut and fill area where immediately visible from the highway.

- Retain natural drainage channels.
  - alter slope to blend with natural drainage or "lay backs" (eg. transition of 2:1 to 3:1 to 4:1 vertical slope).
  - transitional slope is continuous to the most gradual slope, at centre of layback.
  - minimum length of layback at mouth should be equal to 0.5 sec. at highway design speed.
- Retain naturally occurring rock outcrops and ridge lines where feasible.

Figure F-14
These naturally occurring laybacks can be reproduced during earthworks design and construction.

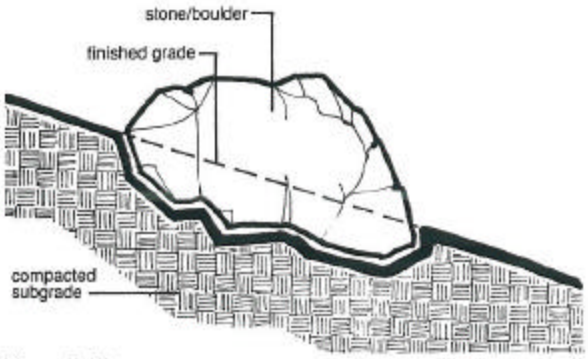

Figure F-15
Grade around rock or rock outcrops so as to maintain a natural appearance.

.4 Avoid disturbance of waterbodies.

- Avoid encroaching fill upon water bodies.
  - maintain, wherever possible, 15m minimum separation between the no-cut/no-fill line and the edge of fish bearing water bodies, 7.5m minimum separation from all other year-round running water courses.*
- Avoid excessive channelling and erosion from cut/fill slopes and ditches.
  - provide transitional "bell mouth" swale and feathering of end slopes where ditches and slopes intersect water courses.**
  - where required for erosion construct rough bed channel of rock material typical in scale to that in the adjacent site.***
- Consider the use of bioengineering techniques.****

**refer to HIGHWAY STRUCTURES for alternative use of retaining walls.*

***refer to CLEARING AND GRUBBING AND REVEGETATION for integration with adjacent vegetation.*

****refer to EARTHWORKS for details of construction*

*****refer to REVEGETATION for bioengineering.*

Figure F-16
Typical 'bell-mouth' swale and related feathering.

.5 Avoid disturbing trees to be retained.

- Avoid disturbance of soil within the tree canopy.
  - limit toe of slope of fill to tree canopy line.
  - allowances may be made where protective retaining walls are impractical. Fill of up to 0.5m over 50% of the root zone is allowed for deep taproot species.*
  - avoid cut within 1m of tree canopy line. **
- Provide fencing and flagging necessary to protect the vegetation to be retained.

.6 Match fill material top dressing with that of adjacent terrain.

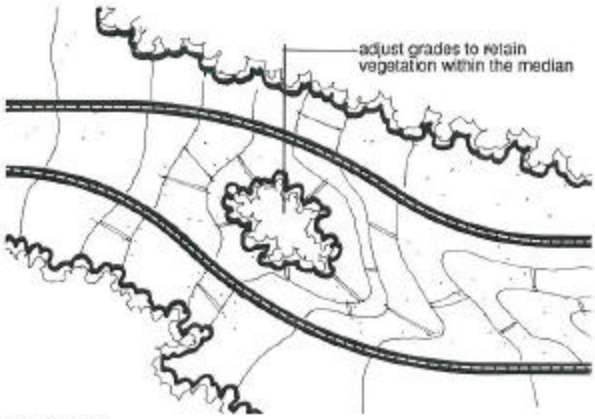

Figure F-17
Design earthworks to avoid damage to trees and vegetation to be retained.

Figure F-18
Avoid fill over the roots of trees to be retained unlike what has been done in this photo.

4.0 Application of Earthwork Guidelines

Apply these standard guidelines for earthworks to all areas impacted by roadway development.

.1 Blast Cuts

- Expose natural rock fractures where slope stability is not a factor.
  - employ random or "wild cat" blasting to best expose or simulate natural rock fractures.
  - avoid or vary pre-split blast lines where visible immediately adjacent to highway.
- Provide non-uniform (staggered) bench sections, where slope stability is a concern.
  - vary the riser height (minimum 2m) to match natural rock strata lines. Provide a minimum 2m wide bench to accommodate revegetation.*
  - additional benches should be constructed using random blasting techniques and created to simulate natural rock features.
- Treat exposed rock face to match adjacent undisturbed site, or to match adjacent cut faces.
  - scarify rock faces to mask blast lines.
  - scarify rock faces and spray liquid fertilizer for rapid revegetation of rock faces.*
  - spray asphalt emulsion to match the colour of all adjacent newly exposed broken rock and that of adjacent undisturbed exposed rock.
- Match the colour of protective wire mesh to that of adjacent undisturbed exposed rock.
- Bury excess scree.
- Recognize the possible need for changes in the field related to the location or form of blast cuts for aesthetic reasons.

refer to REVEGETATION for revegetation and hydroseeding.

Figure F-19
Example of blasted rock face which simulates a natural rock outcrop.

Figure F-20
Example of a smooth wall blasted rock face incorporating benches for stability.

.2 Ditches.

- Minimize the visual impact of the ditch adjacent to the road.
  - limit ditch depth to the minimum required by geotechnical considerations.
  - limit side slope of ditch to maximum 3:1 slope. As adjacent terrain flattens consider more gradual ditch side slopes. (eg. flatlands may use ditch side slopes of up to 14:1).
  - round bottom of ditch.
  - consider perforated drains to drain granular sub-base.

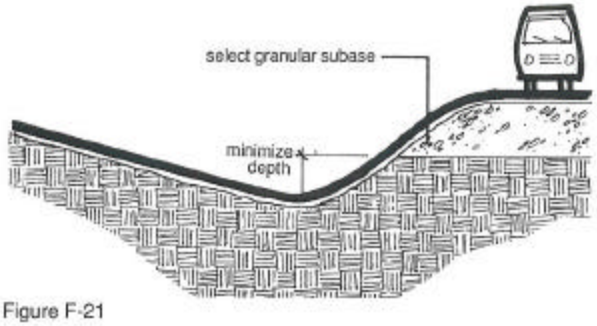

Figure F-21
Avoid excessive depth of ditches.

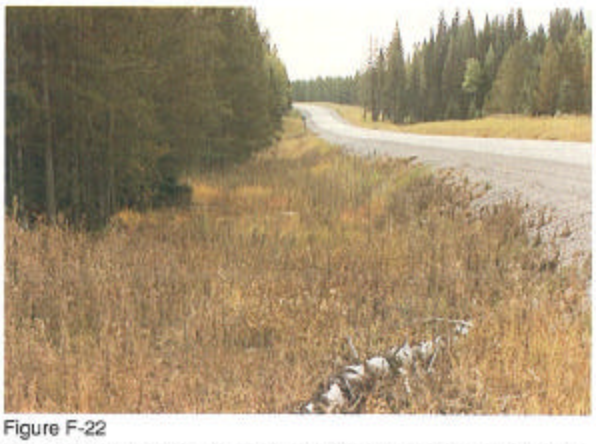

Figure F-22
Make ditch side slopes as flat as practical, and relate to adjacent terrain.

- Integrate ditch with adjacent terrain.
  - vary distance between ditch and pavement edge up to 15m. Change direction of ditch at 15 degrees minimum with 20m minimum radius. For example, change tangent for distance equal to 3 - 5 seconds at highway design minimum speed.
  - provide gradual transition between slopes, maintain angle of slope for 20m minimum.
  - construct a transitional "bell mouth" swale where the ditch intersects with a valley or "lay back".
  - construct a transitional "bell mouth" swale where the ditch requires widening to accommodate increased run-off, or to correct areas prone to siltation or erosion of fill section.

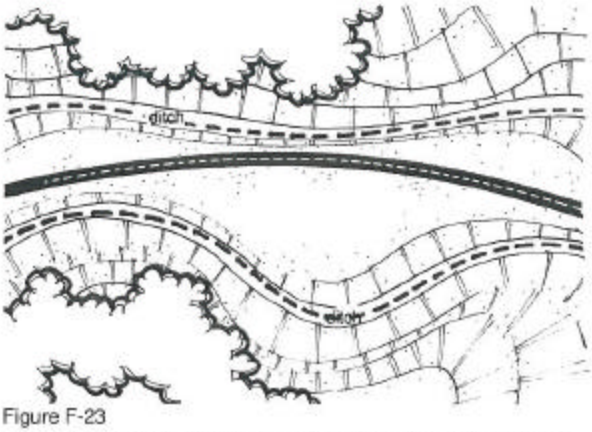

Figure F-23
Ditch alignments need not be parallel with the edge of pavement. Ditches should respond to adjacent terrain.

Figure F-24
Consider perforated drains rather than ditches to drain granular sub-base, where longitudinal slope is adequate.

.3 Medians

- Retain existing ponds, sloughs, and marsh.
  - preferably, maintain 7.5m minimum distance between no-cut/no-fill line and edge, as defined by environmental assessment.
  - where 7.5m minimum distance cannot be complied with, slope at 4:1 maximum.
- Blend created ponds or retention basins to simulate naturally occurring depressions.
  - preferably, provide 20:1 slope for a minimum length of 5m from waters edge.
  - maximum water level to be at 150mm below select granular subbase.
- Minimize the visual impact of ditches.
- Minimize visual impact of median berm.
  - slopes of median berms should be as flat as feasible - not exceeding 3:1.
  - provide berm for mitigation of headlight glare, only if 4:1 or flatter slope is possible.

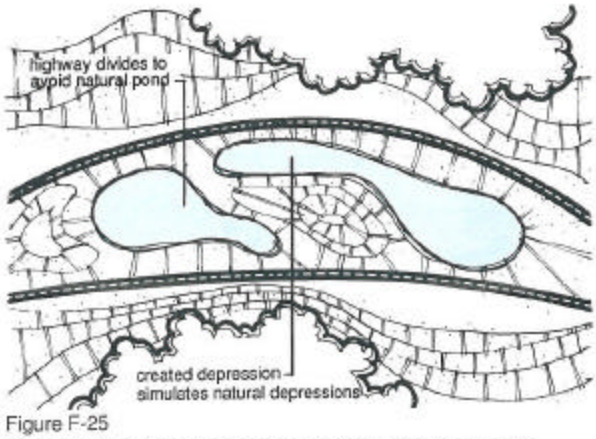

Figure F-25
Blend created ponds or created retention basins to simulate naturally occurring depressions.

.4 Culverts

- Taper or bevel culvert end.
  - taper at a 3:1 maximum slope. Fine grade along entire length of culvert edge.

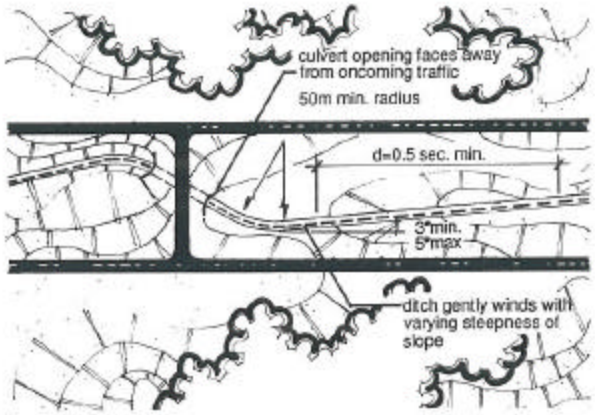

Figure F-26
Minimize the visual impact of ditches and steepness of slopes in medians.

Figure F-27
Typical culvert end with concrete flare. See Figure A-4 for alternate example.

.5 Berms

- Avoid erratic and monotonous screening of unsightly views.*
  - construct berms for a minimum length equal to 0.5 seconds at highway design speed, and a maximum length equal to 10 seconds at highway design speed.
  - warp side slope of berm, with a maximum slope of 4:1, at a distance equal to 0.5 seconds minimum, 5 seconds maximum, and 3 seconds maximum at highway design speed.
  - vary the height of berm from a minimum 1.5m above the finished grade elevation of the highway.
  - provide gaps between berms not exceeding 20m.

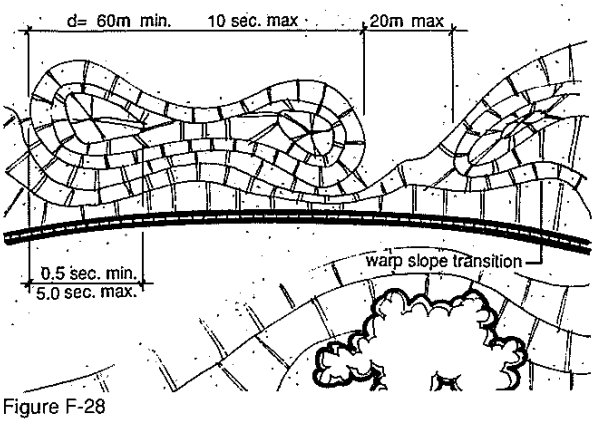

Figure F-28
Construct berms with a varying height, length and alignment to avoid visual monotony.

- Provide effective but attractive screening to mitigate headlight glare.**
  - berms, specifically installed to mitigate headlight glare, should be a minimum length of 60m and a maximum length equal to 10 seconds at highway design speed.
  - provide gaps between berms not exceeding 20m.
  - warp side slope of berm with a maximum slope of 4:1, at a distance equal to 0.5 seconds minimum, and 3 seconds maximum at highway design speed.
  - vary the high point of the berm from a minimum 1.5m above the finished grade elevation of the highway, to a minimum 1.8m where commercial truck traffic predominates.
- Integrate berm with adjacent terrain.
  - vary the distance between the pavement edge and the toe of the berm slope at a minimum distance of 10m.
  - alternately, align the berm to not be parallel with the road. Align berm 5 degrees minimum, 15 degrees maximum off parallel, with minimum curve radius between tangents of 5m.
  - minimum width of warp at toe of slope should be equal to 0.5 seconds at highway design speed.

**refer to ALIGNMENT for appropriate location for berms.*

***refer to VEGETATION MANAGEMENT for combined or alternate use, where these measures prove inadequate.*

.6 Uphill Slopes

- Limit lengths of constant uphill slopes beside the highway.*
  - warp the slope and/or create "laybacks" where slope exceeds distance equal to 5 seconds at highway design speed.
- Warp slope to tie into existing grade at the end of tangent.

.7 Downhill Slopes

- Relax base standards for earthworks where circumstances warrant.
  - consider use of retaining structures where earthwork required to meet grade is excessive in scale.
  - consider use of retaining structures where existing vegetation may be retained to screen road and downhill earthworks.
  - consider use of retaining wall to allow for encroachment of vegetation for variety of enclosure along roadside.

**refer to REVEGETATION for alternate methods of providing variety to slopes.*

.8 Avalanche Barriers

- Integrate avalanche barrier with adjacent terrain.*
  - blend ends of barrier into adjacent slopes.
  - feather the end of slope.
  - blend "lee" side slope with ditch bank slope to give appearance of one contiguous slope.
  - provide a warp, or varied slope, to the "lee" side of avalanche barriers which exceed 5 sec. in length. Maximum side slope should be 4:1. Minimum width of warp at toe of slope should be 0.5 seconds or greater at highway design speed.

**refer above for transition of slopes at end, toe and top.*

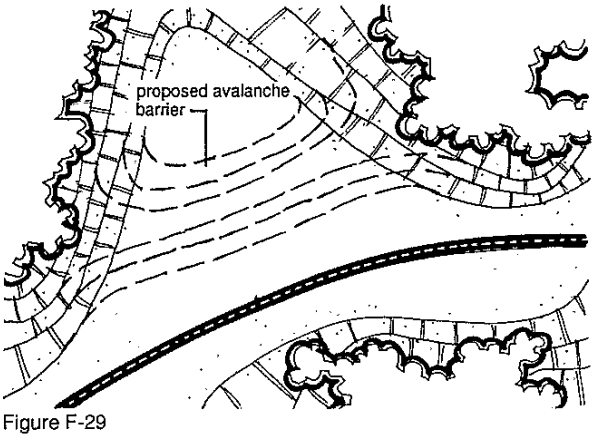

Figure F-29
Blend the ends of the avalanche barrier into adjacent terrain.

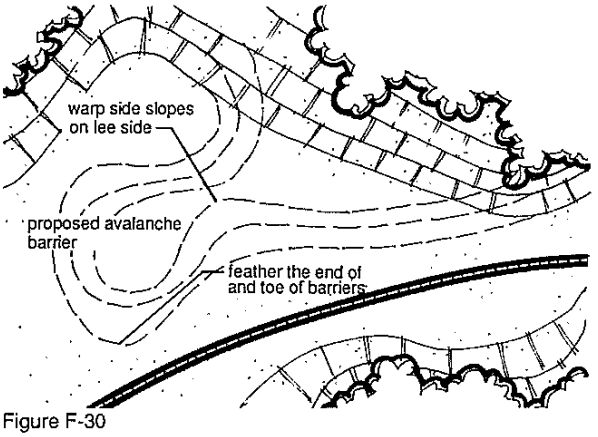

Figure F-30
Feather the toe and warp side slopes on the lee side of the barrier.

.9 Retaining Structures

- Provide a consistent and visually clean silhouette at top of wall. (Applicable to **upslope and downslope** conditions.)
  - top of wall should follow natural terrain to be retained, or reflect roll of natural terrain typical to the region.*
  - for **cribbing** construction, step elevation of top of wall up or down in equal increments.
  - for **poured in place** construction, maintain consistent top of wall, or alternately maintain top of wall at constant slope, for distance stated below.
  - irrespective of natural terrain to be retained, avoid "roller-coaster" effect. Maintain stepping/sloping of wall up or down for a minimum length equal to 0.5 seconds at highway design speed. Constant sloped top of wall should change from up to down slope with 5m minimum radius.
  - meet top of wall with fill for entire length of wall.
- Fit bottom of wall to adjacent terrain. **(Applicable **only to upslope** conditions)
  - parallel the bottom of wall elevation with that of highway elevation.
  - commence slope, at 4:1 maximum, at bottom of wall 1m in front of wall. ***
  - wrap earthwork around the end of wall. Grade earthwork from typical bottom of wall elevation, commencing at a maximum of one-third of the total length of the wall, from the end of the wall, at a maximum 3:1 slope.
  - at the end of wall, the earthwork should meet the top of wall. Alternatively, if a no post traffic barrier must be placed at the end of the wall, the wall height should be equal and integrated flush with the traffic barrier. Material may be retained behind the traffic barrier.

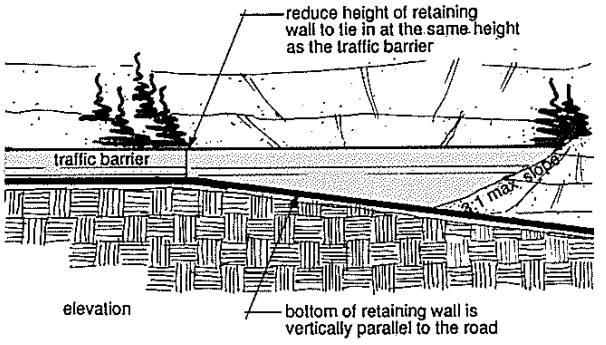

Figure F-31
Elevation of typical retaining structure.

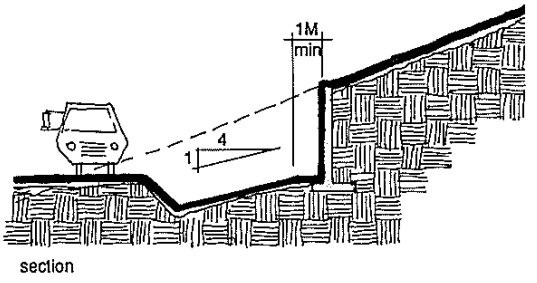

Figure F-32
Section through typical retaining structure.

refer to REVEGETATION for revegetation at top of wall.

***refer to HIGHWAY STRUCTURES for height of walls.*

****refer to REVEGETATION for revegetation at bottom of retaining structures.*

.10 Bridges

- Screen the spring point of the bridge from the approach angle of highway. Heighten the dramatic relief once on the bridge.
  - *maintain cut as close as feasible to the road.*
- Alternatively, visually open a view from the approach angle of the highway.
  - grade so that the view is opened toward the bridge.
  - provide terrace for viewing of bridge commensurate to safety requirements. Provide a terrace 15m minimum width, 20m minimum length, at a maximum cross slope of 6%. This will accommodate revegetation and/or future possible pullout/rest area.

.11 Overpasses

- Accentuate intended silhouette of overpass design.
  - limit slope under a span to 2:1 maximum, feathering ends of slope to adjacent terrain.
  - retaining devices should be integrated with adjacent traffic barriers and tapered into adjacent slopes.

.12 Interchanges

- Treat ramps and adjacent terrain as one integrated form.
  - where applicable blend ramp slope into retained pond, slough, and marsh, or created retention basin.
  - slope ramp side slopes at 4:1 maximum.
- Emphasize decreasing or increasing design speed of ramp.*
  - flatten side slopes of ramp and ditches in proportion to desired increase in speed.
  - steepen side slopes of ramp and ditches in proportion to desired decrease in speed.
  - decrease the distance between the pavement edge and the toe of berms in proportion to desired decrease in speed.

**refer to ALIGNMENT for maximum heights allowed within sight triangles and distances.*

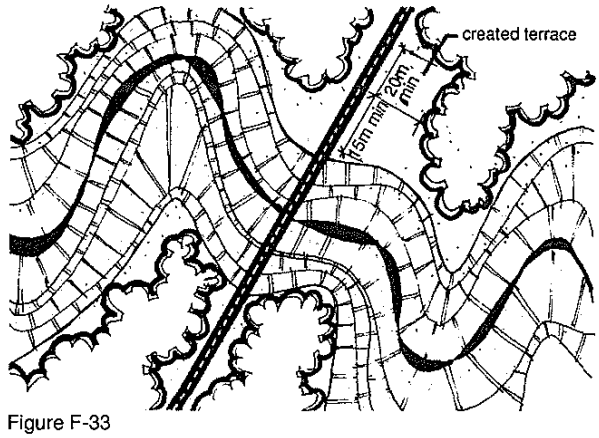

Figure F-33
Create a terrace at bridge spring point.

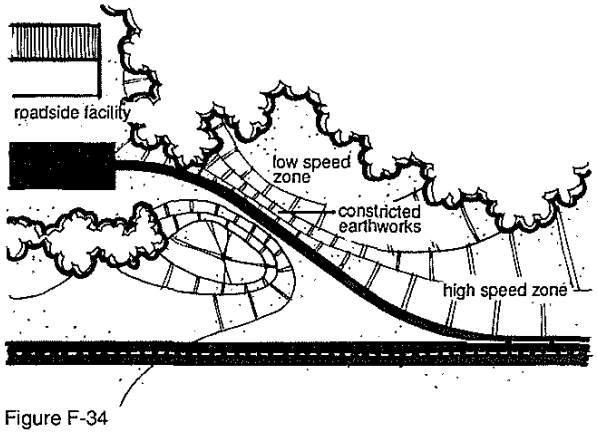

Figure F-34
Emphasize design speed changes with earthworks.

.13 Roadside Facilities

- Avoid ditches directly adjacent to roadside facility access road, parking areas, and walkways.
  - preferably, align ditches to the facilities site perimeter.
- Minimize the visual impact of ditches which must appear adjacent to roads, parking areas, and walkways.
  - set back ditch top of slope 1.5m from edge of pavement edge or walkway.
  - maintain the minimum possible depth of ditch.
  - width of ditch, measured from top of slope to top of slope, should be six times the depth of ditch.
- Eliminate ditches wherever possible.
  - facilitate drainage over pavement.
  - facilitate drainage by underground pipe or drain.
- Facilitate access by the physically challenged to site.
  - maintain 20:1 maximum slope for parking areas, and internal roads.
  - maintain 8:1 maximum slope for curb ramps.
  - maintain 20:1 maximum slope for primary walkways. Where required, primary walkways may be 12:1, with maximum distance between landings 9m, landings minimum 3m in length. A 920mm high rail on one side should be provided.
  - maintain 10:1 maximum slope for secondary walkways (no rails, personal assistance).
  - maintain 30:1 maximum slope for a 1.8m distance on all sides of picnic tables, seating, and facility entrances.
- Emphasize desired road speeds and attention to pedestrian/vehicle conflicts.
  - maintain 600mm maximum height of vegetation above finished road elevation, within sight triangles at the intersection of roads.
  - maintain 300mm maximum height above finished road elevation, within sight triangle at the intersection between roads and parking areas and walkways.

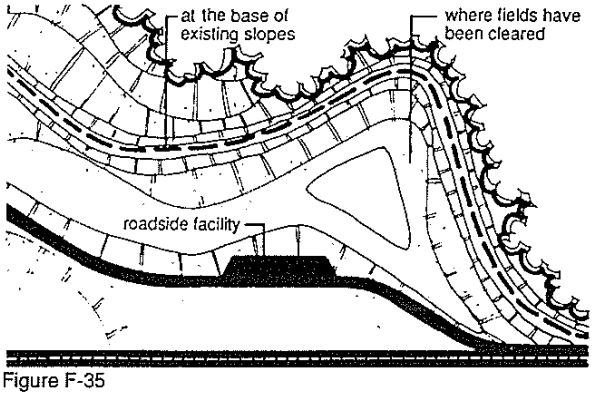

Figure F-35
Align ditches at roadside facilities to be the least visible, usually at the site perimeter.

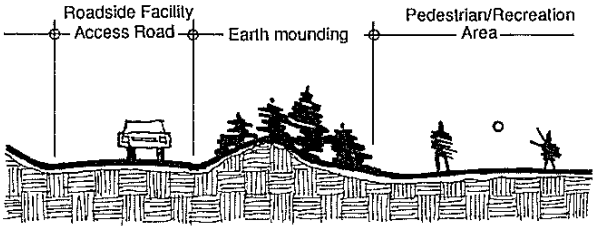

Figure F-36
Earthwork techniques can emphasize roadway speed limits and reduce pedestrian/vehicle conflicts.