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4.0 EARTHWORK ESTIMATES AND HAUL ANALYSIS

4.1 INTRODUCTION

This section contains criteria for performing earthwork estimates and haul analyses for the gas pipeline project.

Parameters effecting earthwork estimates and haul analyses are identified in this section and design procedures are discussed including quantity estimates, earthwork factors, grading considerations, and haul segments.

Criteria that define earthen materials are found in Sections 9 and 13 and are not included here. Additionally, design criteria for restoration are presented in Section 12 and Drainage and Erosion Control in Section 11. There are no calculations presented in this section.

4.2 CODES AND CRITERIA

4.2.1 Codes

- Federal Right-of-Way (ROW) Grant for the Alaska Natural Gas Transportation System Alaska Segment, Serial No. F-24538 (December 1, 1980), as such may be updated and/or amended from time to time
- Code of Federal Regulations, Title 18 - Conservation of Power and Water Resources
- Federal Energy Regulatory Commission conditional certificate of public convenience and necessity, issued on December 16, 1977, as such is finalized

4.2.2 Criteria

4.2.2.1 General

Earthwork quantity estimates and the mass haul analyses are performed to evaluate the total extent of civil construction requirements including:

- Locations and demand for borrow materials
- Locations and the volume of excess materials for disposal
- Earthwork for construction traffic

The criteria in this section establish the guidelines for earthwork estimates and mass haul analyses by:

- Identifying the mineral materials which are to be considered, (see Sections 5, 6, 7, 8, 9, 11, 12, 13, 15, 16, 21, 22, 23, 24, and 28)
- Identifying the limiting physical and practical features

- Defining the factors that are used in the engineering estimates of construction requirements

4.2.2.2 Elements of the Design Estimates and Analyses

The following elements are considered in the preparation of engineering earthwork estimates, the delineation of haul segments, and the mass haul analyses:

- Volumes of embankment and excavation material for the workpad and staging areas
- Volumes of excavation and backfill material for the gas pipeline ditch
- Volumes of excavation, backfill, and embankment material for road, pipeline, river, stream, and wetland crossings and valve and gas delivery sites
- Volumes of embankment and excavation material for compressor and meter stations
- Volumes of embankment and excavation material for access roads, camps, airports, storage yards, disposal sites, and solid waste disposal sites
- Volumes of riprap for erosion control, spur dikes, and revetments
- Volumes of maintenance materials for the construction period
- Volumes of materials required for restoration
- Usability of material as determined by the geotechnical properties
- Swell and shrinkage during excavation and placement
- Losses in hauling and handling
- Construction schedules, sequences, and methods
- Environmental aspects, such as:
  - fish and wildlife habitat
  - wetlands
  - archaeological sites
- Impact on existing facilities, including roads, bridges, and pipelines
- Location and availability of borrow materials
- Location and availability of spoil disposal areas
- Lengths, grades, conditions, and features, such as towns, crossed by haul routes

4.2.2.3 Unit Quantities

The unit quantities used in summarizing design quantity estimates and mass haul analyses are cubic yards (cu yd) of volume and miles (mi) of haul distance. Quantities summarized on the construction plans will be template volumes without adjustment factors and haul distances. Volume estimates used in design studies, construction planning, and cost estimating will be

determined by applying appropriate factors to the template volumes. Unit quantities of measurement for payment will be developed during detailed construction planning and incorporated in the construction contract documents.

4.3 DESIGN PROCEDURES

4.3.1 Estimate of Quantities

Estimates of quantities will be based on volumes calculated from plan dimensions and original ground surface measurements obtained from field surveys or topographic maps. Subsurface conditions will be determined by interpreting boring logs and other geotechnical data. The following methods and factors will be used to estimate quantities for summaries.

4.3.1.1 Construction Zone Grading and Access Roads

Estimated quantities of embankment and excavation materials for construction zone grading and access roads will be determined by the average end-area method. End areas will be determined by applying the design templates to the ground surface as determined by cross-section surveys. Estimated volumes will be determined by averaging the end areas of two adjacent survey cross sections and multiplying by the surveyed distance between the cross sections. (Note: Design survey cross sections are taken at 200-foot intervals and breaks in terrain.) Adjustment factors are not included in these calculations. Estimated quantities will be determined and recorded as follows:

- Embankment material quantities are the summations of fill volumes included in:
  - workpad
  - staging areas
  - ramps
  - berms
  - access roads
  - special construction, such as spur dikes and revetments

  Embankments will be constructed using materials that meet the criteria in Section 9. Material sources may be material sites (also called “borrow” sites) or ROW excavation.

- Excavation quantities are the summations of cut volumes included in:
  - stripping
  - benching
  - through cuts

  - side hill cuts
- Geotechnical aspects will be considered to categorize all excavated quantities and pipeline segments into the following:
  - Useable material for embankment (see Section 9)
  - Areas where useable materials are excess, cannot stay on the immediate ROW, and are not needed on adjacent segments and so must be spoiled on adjacent segments, spoil disposal sites, or material sites.
  - Areas where unusable materials cannot stay in the immediate ROW and so must be spoiled on adjacent segments, spoil disposal sites, or material sites.
- Factors for adjusting construction zone grading and access road volumes to estimated construction requirements will be based on site-specific data. Factors for use in design studies are included in Table 4-1.

4.3.1.2 Site Grading

Quantities of embankment and excavation for site grading will be determined for each of the following:

- storage yards
- spoil disposal sites and solid waste disposal sites
- compressor and meter stations
- camps and airports

Volumes will be calculated by applying the templates and grades shown on the plans to topographic maps of the original ground surface.

- Embankment materials are the summations of fill volumes included in
  - pads
  - levees
  - berms
  - surface courses

  Embankments will be constructed using materials that meet the criteria in Section 9. Material sources may be material sites or onsite excavations.

- Excavation quantities are summations of cut volumes included in:
  - stripping
  - benching
  - site grading

- Geotechnical aspects will be considered to categorize all excavated quantities into the following:
  - Material useable for embankments (see Section 9)
  - Useable material that must be spoiled on adjacent areas, spoil disposal, or material sites because it is excess, cannot stay on the immediate site, and is not needed on adjacent areas
  - Unusable material that must be spoiled in spoil disposal or material sites
- Earthwork factors for adjusting site-grading volumes to estimated construction requirements will be based on site-specific data. Factors for use in design studies are included in Table 4-1.

4.3.1.3 Pipeline Ditch Excavation

Excavation quantities from the pipeline ditch will be estimated by applying the lengths shown on the pipeline construction drawings and the pipe ditch typicals (see pipe ditch typical drawings in Section 13).

- Excavation quantities are the summations of the cut volumes from:
  - The pipeline ditch
  - Site-specific excavations – stream crossings, road crossings, etc.
- Consideration will be given to geotechnical information to categorize all excavated quantities into the following:
  - Material useable for common backfill or bedding and padding (see Section 13 for material criteria)
  - Useable material that must be spoiled on adjacent areas, spoil disposal, or material sites because it is excess, cannot stay on the immediate ROW, and is not needed on adjacent segments
  - Unusable material that must be spoiled in spoil disposal or material sites
- Earthwork factors for adjusting pipe ditch excavation volumes to estimated construction requirements for use in design studies are included in Table 4-1.

4.3.1.4 Pipe Ditch Backfill

The pipeline ditch typicals (see pipe ditch typical drawings in Section 13) and the pipeline construction drawings will be used to determine backfill quantities. Deductions for the volume occupied by the pipe and insulation will be made.

- Backfill material (see Section 13) quantities will be grouped as follows:
  - Common backfill from ditch excavation
  - Select backfill from material sites

  - Bedding and padding material from material sites
  - Non frost-susceptible material
  - Bedding and padding material from ditch excavation
- Earthwork factors for adjusting pipe ditch backfill volumes to estimated construction requirements will be based on site-specific data. Factors for use in design studies are included in Table 4-1.

4.3.1.5 Miscellaneous Materials

- Quantities will be estimated from the construction plans for specific need miscellaneous materials. These materials will include:
  - Riprap for spur dikes and revetments
  - Traffic surface courses
  - Traffic stable material for low water crossings
  - Bedding and padding for culverts
  - Riprap, channel lining and filters for erosion control
  - Concrete aggregate
  - Bedding and lining material for petroleum storage/ fueling areas and steam cleaning areas
  - Materials for restoration
- Quantities for embankment materials that will be used for repairs and maintenance of the workpad will be estimated from the construction plans. Earthwork factors for adjusting volumes of maintenance materials for use in design studies are included in Table 4-1.

4.3.2 Material Site Target Quantities

Although earthen materials resulting from grading and ditching operations will be used for embankment construction and backfill to the greatest extent possible, large quantities for embankment construction and backfill will have to be "borrowed" from outside sources. These outside sources will be designated as project mineral material sites (borrow sites), to be located, evaluated, and developed in accordance with criteria and procedures presented in Section 5.

The quantities of borrow required from mineral material sites will be established by procedures described herein. The required in-place reserves to be proven at individual sites, or at a group of sites over a construction spread segment, will be referred to as target quantities. These target quantities will include sufficient reserve deposits to provide contingency for:

- Agency rejections or restrictions on site development
- Geological uncertainties
- Possible future increases in construction quantity requirements
- Site-to-site transfers of purchase quantities within given contract sales

As the level of confidence in estimates of available reserves increases as the material site identification process advances through the stages of site selection, evaluation, and mining plan development, the allowed contingency for each phase can decrease. The contingency requirement for target quantities at various phases is as follows:

- Field exploration-Approximately 200 percent of the estimated construction requirement should be identified in reserves evaluated and proven upon completion of field exploration.
- Mining plans-Approximately 150 percent of the estimated construction requirement should be identified as available in work areas provided for in finished mining plans submitted with Mineral Material Acquisition Plan (MMAP) packages, to be developed.

4.3.3 Haul Analyses

Haul analyses will be performed to estimate the hauling necessary to move earthen materials from available sources to required locations. Analyses will include estimates for alternate designs given in Section 9 and for hauling unusable and excess materials to acceptable disposal areas. While no monetary values are used in the haul analyses, the results will provide input for cost estimating and evaluating impacts to the environment and other facilities.

4.3.3.1 Haul Segments

The haul analyses will be performed on a segment-by-segment basis for each category of material to be moved. The following are considered in the establishment and analysis of each segment:

- Limits of segments for each category of material will be selected to provide timing consistent with construction schedules, sequences and environmental considerations.
- Limits of segments will be selected to provide a balance of materials. That is, demands will not exceed availability within each segment. Fill, backfill or miscellaneous materials plus shrinkage and losses will come from excavation within the segment. Excavated materials plus swell will go to fills, backfill, restoration, losses, or disposal within the segment.
- Haul routes within a segment will be selected to provide the shortest practical distance. Alternate routes that are necessary to avoid crossing pipelines, highways,

bridges, towns, sensitive environmental areas or difficult construction locations will be included as required.

4.3.3.2 Analyses Summaries

The haul analyses will be summarized by geographical areas of interest according to the following topics:

- Construction zone grading and access roads
- Pipeline ditch excavation and backfill
- Site-specific grading
- Borrow materials
- Spoil disposal

Table 4-1 Earthwork Factors – Civil Design Studies

These factors are not to be used for final design or bid quantity estimates, but rather for design studies which compare alternates.

Construction Zone Grading (Workpad Construction)

Embankment Construction Requirements

Net shrink/swell (during embankment construction)	=	-14.33%
Spillage (during embankment construction)	=	- 2.00%
Maintenance (after embankment construction)	=	-13.67%
Total Loss and Construction Maintenance	=	-30.00%

$\frac{1}{1.0 - 0.3}$ = 1.4286 cu yd @ excavation site to provide 1.0 cu yd in embankments, constructed and maintained.

$\frac{1}{1.00 - 0.1633}$ = 1.1952 cu yd @ excavation site to provide 1.0 cu yd in embankments, initial construction.

$1.4286 - 1.1952$ = 0.2334 cu yd @ excavation site[1] to provide construction maintenance of 1.0 cu yd in embankments.

Embankment from Material Sites

Initial construction quantity	=	1.1952 × template volume of embankments constructed from material sites.
Construction maintenance quantity	=	0.2334 × template volume of all workpad and access road embankments.

Embankment from Cut Sections

Initial construction quantity	=	1.2345 × template volumes of embankments constructed from cut sections.
Construction maintenance quantity	=	None

Excavation from Cut Section

Useable material for embankments

1.0 cu yd in cut section = 1.00 - 0.20 = 0.80 cu yd in embankment.

Excess material for disposal

1.0 cu yd in cut section = 1.0 cu yd for disposal.

Pipeline Ditch (Excavation and Backfill)

Ditch Excavation

Stable ditch excavation	=	Ditch template volumes (1/4:1, side slopes) plus 25% for standard over-excavation.

[1] All construction maintenance materials are from material sites.

Unstable ditch excavation	=	Ditch template volumes (1/2:1 side slopes) plus 70% for sloughage and over-excavation.

Useable Materials for Common Backfill

Net shrink/swell (during backfilling)		=	-13.00%
Spillage (during backfilling)		=	- 2.00%
	Total Losses	=	-15.00%
1.0 cu yd in ditch excavation			1.00 -0.15 = 0.85 cu yd in common backfill

Useable Materials for Special Backfill

Net shrink/swell (during backfilling)		=	-11.00%
Spillage (during backfilling)		=	- 2.00%
	Total Losses	=	-13.00%
1.0 cu yd in ditch excavation			1.00 - 0.13 = 0.87 cu yd in common backfill

Excess Materials for Disposal

1.0 cu yd in ditch excavation	=	1.0 cu yd for disposal

Ditch Backfill

Stable ditch backfill	=	Ditch template volumes (¼:1 side slopes) minus pipe and insulation volumes plus 25%.
Unstable ditch backfill	=	Ditch template volumes (½:1 side slopes) minus pipe and insulation volumes plus 70%.

Common backfill construction requirements

$$\frac{1}{1.00 - 0.15} =$$ 1.1765 cu yd @ excavation site to provide 1.0 cu yd of common backfill in ditch

Special backfill construction requirements

$$\frac{1}{1.00 - 0.13} =$$ 1.1494 cu yd @ excavation site to provide 1.0 cu yd of special backfill in ditch.