# 14. ENGINEERING AND CONSTRUCTION SCHEDULES

*The project procurement strategy and contract strategy – based on the project risk profile – have not yet been formulated. For the purposes of completing the construction planning and estimating recorded in Sections 13 and 14, a procurement strategy has been assumed that is a "best estimate" of an appropriate strategy, based on worldwide experience of similar project development of similar size and complexity under a similar risk profile.*

## 14.1. Preparation of Schedules

This Section presents the proposed project Engineering and Construction Schedules, based on the selected project arrangement and major features presented in Sections 8, 10, and 11. Originally, the schedule was created to include the activities required for preparing the Federal Energy Regulatory Commission (FERC) license application. Because of legislative uncertainty, and uncertainty associated with the FERC licensing schedule, for this report – to assist in understanding the governing technical challenges of the project – the Engineering and Construction schedule has been "decoupled" from the FERC licensing schedule, although a key "predecessor" for any, and all, construction is the issue of a FERC license and the completion of associated reviews and permitting. A comprehensive integrated schedule will be prepared separately by Alaska Energy Authority (AEA) during subsequent stages of project development.

A significant driver for the schedule is the necessity for a comprehensive site geotechnical investigation program and excavation of adits in the dam abutments which are required to establish more definitive foundation characterization to support feasibility and detailed design. Some basic site investigation has been undertaken in 2014, but – because of the unpredictability of the annual budget cycle – no certainty is attached to future funding of site investigation vital to support feasibility and detailed design. To accommodate these uncertainties surrounding project implementation, it was decided to prepare a design and construction schedule "without links" to the process of FERC licensing, and simply organized by year following any decision to initiate continuous project development – evidenced by the start of a linked site investigation and detailed design.

Please refer to Appendix B11 for the comprehensive Susitna-Watana Engineering and Construction Schedule.

### 14.1.1. Calendar

Although the pre-construction activities will be performed on the basis of an "office" (i.e. 5-day work week) calendar, there are also two different calendars applying to construction work on the site (described below), together with some key constraints.

The weather at the site is a major factor, particularly the arduous winter weather which will have a significant effect on the various contractors construction scheduling.

Certain activities can be continued during the winter economically and productively, as demonstrated during the construction of the recent Karahnjukar hydro project in Iceland. These activities include:

- underground works (tunneling);
- conventional concreting, which can be performed under temporary insulated weather protection;
- quarry development, and rock excavation can also be continued under adverse conditions, but it is expected that the output will be compromised somewhat during inclement weather;
- overburden removal and the associated foundation rock excavation;
- curtain grouting from within the galleries in the dam;
- road construction, which may be able be performed in winter, depending on the geotechnical conditions in the corridor and moisture and density controls; and,
- all activities within the powerhouse, after weather proofing of the powerhouse structure.

There are also activities that are most appropriately and efficiently conducted during the winter months, when the river level is low, such as:

- cofferdam construction;
- river diversion; and,
- permanent road bridge construction.

In contrast, there are significant activities that, at this stage of planning, must be assumed to be carried out only during summer months, which in a typical year is effectively only a five to six month window. Principal among these are the final shaping of the dam foundations, the consolidation grouting of the dam foundations, and the placement of roller compacted concrete (RCC). The current project schedule places RCC on the left and right abutments until such time

as the cofferdams are constructed, the river diverted and the center portion of the dam is available to place RCC.

The challenge for a contractor will be to organize all RCC placement activities in such a way that the season "shoulders" are extended as much as possible, particularly the period of September and October, to maintain production before having to shut down for the winter.

Because of the two parallel "controls" on work, two calendars have been used for construction activities in the Primavera P6 scheduling software, one based on normal working weeks (including public holidays), and a second including specific winter shutdowns.

### 14.1.2. Constraints

In addition to the nuances of summer and winter construction, one key environmental constraint has been included at this time – that is, the effect of migratory birds – which means that no clearing can be performed during bird nesting season. To comply with this regulation, initial clearing will take place in the winter season.

Although activities leading up to the issue of a FERC license have not been included in the schedule, it has been assumed that no construction work of any kind – including the access road – can be commenced before the award of a FERC license and the associated approvals by FERC, and the issuance of permits, most particularly the Corps of Engineers Section 404 permit.

This constraint on construction is particularly important because access to the site is currently considered to be within the licensed works and the access road (which is some 50-60 miles long) is the sole method of mobilization and hence on the critical path of the whole project development.

As discussed in Section 13, construction is assumed to be implemented in seven construction packages and one supply contract, with (essentially) all implementation being performed under a traditional sequence of an engineering design contract, followed by a construction contract. It has also been assumed that at least four contracts will be let for the provision of services such as railroad service, and aircraft operation.

### 14.1.3. Individual Contract Schedules

In deriving the comprehensive Engineering and Construction Schedule, six "break out" schedules were created for the assumed construction contracts:

- Clearing
- Permanent Access Road

- Rail Siding
- Camp and Airstrip Civil Works
- Camp and Airstrip Buildings
- Main Civil Contracts

They are shown below in Figure 14.1-1 through Figure 14.1-6.

**Susitna-Watana Hydroelectric Project - Clearing Construction Schedule**

| Activity ID | Activity Name | Original Duration | Total Float |
|---|---|---|---|
| Susitna-Watana Hydroelectric Project - Engineerin... | | 526.1d | 743.0d |
| Construction Activities | | 526.1d | 743.0d |
| Clearing | | 526.1d | 743.0d |
| S01 | Clearing NTP | 0.0d | 134.1d |
| S02 | Mobilization | 5.0d | 134.1d |
| S03 | Permanent Village Clearing (56 Acres) | 12.0d | 134.1d |
| S04 | Clearing Camp & Contractor Yard (80.7 Acres) | 16.0d | 134.1d |
| S05 | Camp Roads Clearing (31 Acres) | 16.0d | 134.1d |
| S06 | Airport Clearing (160 Acres) | 20.0d | 134.1d |
| S07 | Dam Site Clearing (50 Acres) | 11.0d | 134.1d |
| S10 | Site Access Roads - North & South (141.9 Acres) | 26.0d | 134.1d |
| S20 | End Dam Site Clearing | 0.0d | 134.1d |
| S60 | Reservoir Clearing (2,887 Acres) | 584.0d | 814.0d |

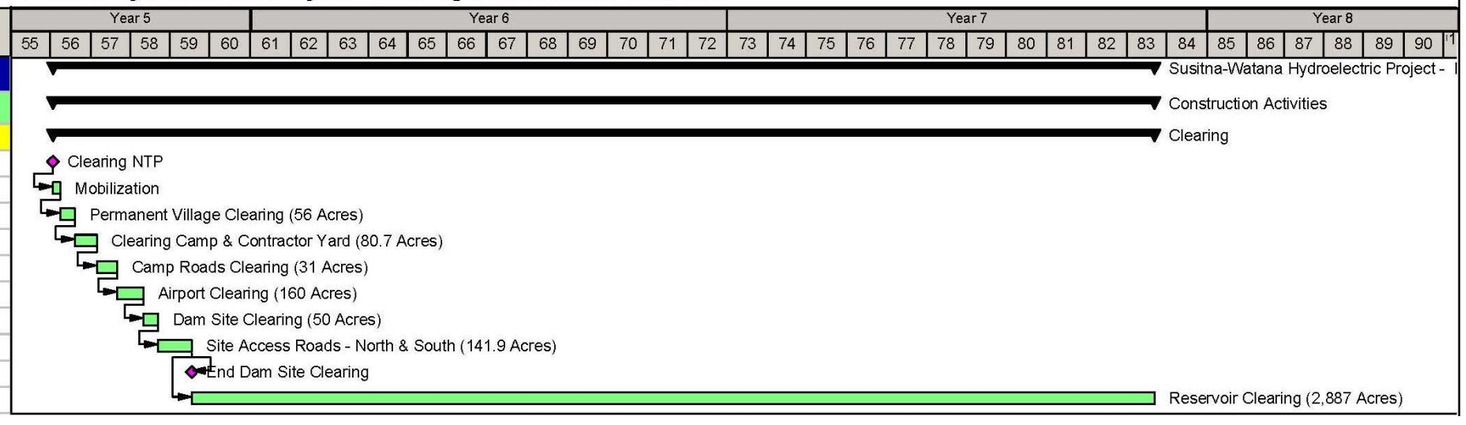



**Figure 14.1-1. Clearing Construction Schedule**

**Susitna-Watana Hydroelectric Project - Permanent Access Road Construction Schedule**

| Activity ID | Activity Name | Original Duration | Total Float |
|---|---|---|---|
| Susitna-Watana Hydroelectric Project - Engineerin... | | 646.0d | 2486.0d |
| Construction Activities | | 646.0d | 2486.0d |
| Permanent Access Road | | 646.0d | 2486.0d |
| S1084 | Permanent Access Road NTP | 0.0d | 0.1d |
| S1085 | Mobilize Crews for Site Access | 24.0d | 3.1d |
| S1090 | Pioneer to Center of 40 Mile Road | 15.0d | 3.1d |
| S1095 | Clearing & Grubbing | 125.0d | 0.1d |
| S1100 | Erosion & Sediment Controls (1st Season) | 147.0d | 561.1d |
| S1105 | Permanent Access Road - Excavation Common (1st Season) | 146.0d | 0.1d |
| S1115 | Permanent Access Road - Excavation Rock (1st Season) | 146.0d | 0.1d |
| S1120 | Permanent Access Road - Embankment (1st Season) | 146.0d | 0.1d |
| S1121 | Winter Shutdown | 212.0d | 0.1d |
| S1130 | Erosion & Sediment Controls (2nd Season) | 74.0d | 186.1d |
| S1135 | Permanent Access Road - Excavation Common (2nd Season) | 74.0d | 186.1d |
| S1140 | Permanent Access Road - Excavation Rock (2nd Season) | 74.0d | 186.1d |
| S1145 | Permanent Access Road Embankment (2nd Season) | 74.0d | 186.1d |
| S1150 | S1 Road (Main Access Road to Bridge) | 18.0d | 2975.0d |
| S1155 | Place Organics on Slopes | 70.0d | 186.1d |
| S1160 | Gravel Surfacing | 40.0d | 234.1d |
| S1170 | Permanent Access Road Long Span Bridge (MP 5.8) | 30.0d | 3.1d |
| S1175 | Permanent Access Road Long Span Bridge (MP 14.9) | 40.0d | 3.1d |
| S1180 | Permanent Access Road Long Span Bridge (MP 15.1) | 30.0d | 3.1d |
| S1185 | Permanent Access Road Long Span Bridge (MP 17.3) | 30.0d | 3.1d |
| S1190 | Permanent Access Road Long Span Bridge (MP 21.6) | 45.0d | 0.1d |
| S1195 | Permanent Access Road Long Span Bridge (MP 26) | 40.0d | 0.1d |
| S1200 | Permanent Access Road Long Span Bridge (MP 43) | 40.0d | 0.1d |
| S1205 | Permanent Access Road Drainage | 53.0d | 274.1d |
| S1210 | Guard Rail | 200.0d | 274.1d |
| S1215 | Rip Rap | 24.0d | 274.1d |
| S1225 | Seeding | 88.0d | 186.1d |
| S1230 | 24.9 kV System Inc Transmission (& Fiberoptics) from Intertie | 72.0d | 244.1d |
| S1235 | Demobilization | 30.0d | 244.1d |
| S1240 | Permanent Access Road Construction Complete | 0.0d | 186.1d |

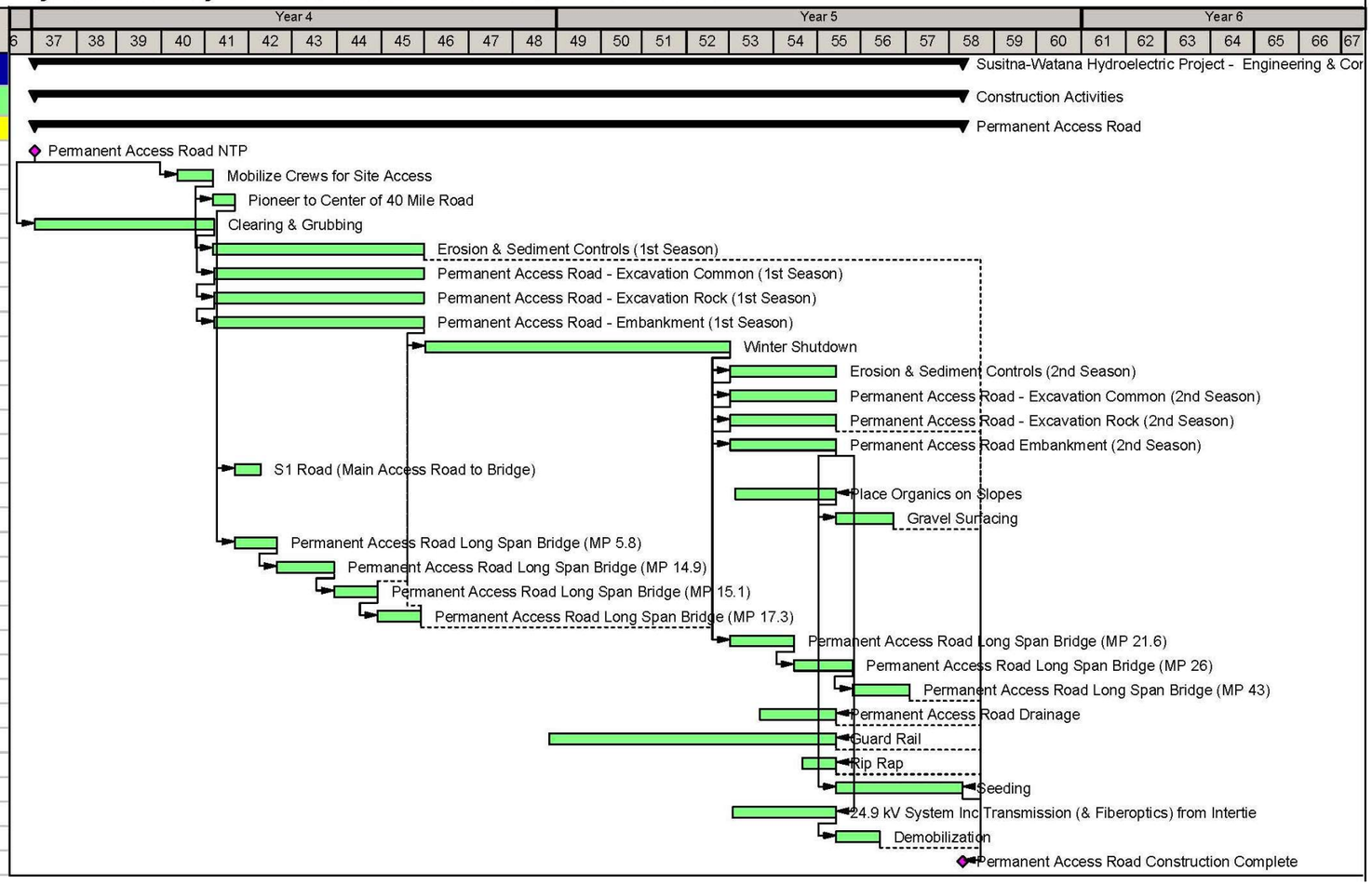



**Figure 14.1-2. Permanent Access Road Construction Schedule**

**Susitna-Watana Hydroelectric Project - Rail Siding Construction Schedule**

| Activity ID | Activity Name | Original Duration | Total Float |
|---|---|---|---|
| **Susitna-Watana Hydroelectric Project - Engineerin...** | | 201.0d | 542.1d |
| **Construction Activities** | | 201.0d | 542.1d |
| **Rail Siding Construction** | | 201.0d | 542.1d |
| S1001 | NTP Rail Siding | 0.0d | 542.1d |
| S1002 | Mobilization | 10.0d | 542.1d |
| S1003 | Construct 350 Man Camp | 20.0d | 542.1d |
| S1004 | Clearing & Grubbing (40 Acres) | 20.0d | 542.1d |
| S1005 | Common Excavation (300,000 CY) | 50.0d | 542.1d |
| S1010 | Borrow Selected Material (210,000 CY) | 50.0d | 542.1d |
| S1015 | Grading D-1 Subballast (40,000 CY) | 10.0d | 542.1d |
| S1020 | Seeding (7 Acres) | 2.0d | 585.1d |
| S1025 | Geogrid (135,000 SY) | 50.0d | 597.1d |
| S1030 | Ballasted Track In Place (115 LB Rail / Wood Ties / 11,900 FT) | 45.0d | 542.1d |
| S1035 | Turnout, Non-PTC Ready, ARRC std. No. 11 115# (2 EA) | 6.0d | 581.1d |
| S1040 | Turnout AARC std. No.11 115# PTC Ready (2 EA) | 6.0d | 581.1d |
| S1045 | Concrete Storage Area (45,000 SF) | 12.0d | 585.1d |
| S1050 | Covered Storage Area (20,000 SF) | 20.0d | 577.1d |
| S1060 | Helipad (10,000 SF) | 15.0d | 582.1d |
| S1065 | Transfer Ramp Loading | 15.0d | 582.1d |
| S1070 | Maintenance Shop (13,200 SF) | 24.0d | 573.1d |
| S1075 | Demobilization | 10.0d | 542.1d |
| S1080 | Rail Siding Construction Complete | 0.0d | 542.1d |

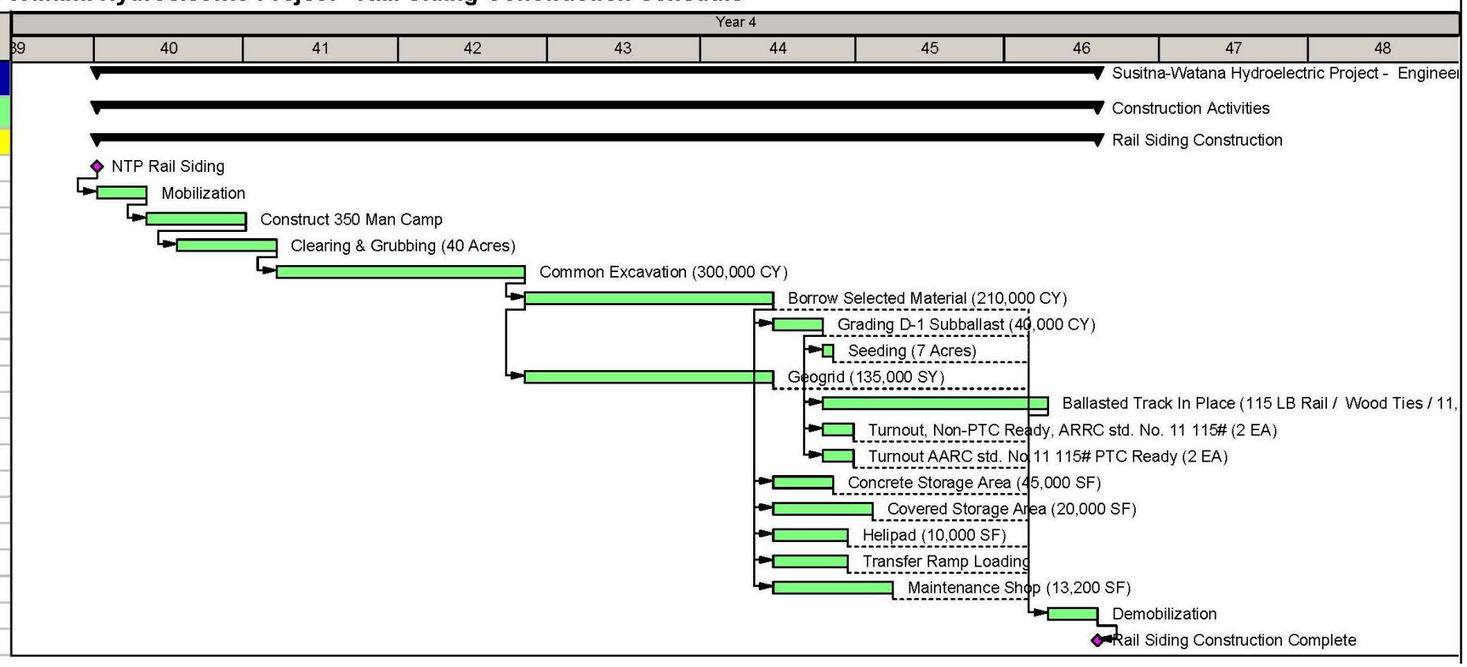



**Figure 14.1-3. Rail Siding Construction Schedule**

### 14.1.3.1. Camp and Airstrip Civil Works Schedule

**Susitna-Watana Hydroelectric Project - Camp & Airstrip Civil Works Construction Schedule**

| Activity ID | Activity Name | Original Duration | Total Float |
|---|---|---|---|
| **Susitna-Watana Hydroelectric Project - Engineerin...** | | 220.0d | 935.1d |
| **Construction Activities** | | 220.0d | 935.1d |
| **Building, Camp & Airstrip Civil Works** | | 220.0d | 935.1d |
| S1439 | NTP Building, Camp & Airstrip | 0.0d | 494.1d |
| S1440 | Snow Road from the North | 10.0d | 494.1d |
| S1495 | Temporary Camp | 20.0d | 514.1d |
| S1550 | Mobilization / SWPPP | 10.0d | 558.1d |
| S1660 | Clearing | 40.0d | 494.1d |
| S1715 | N2 Road (N1 Road to Construction Camp) | 30.0d | 722.1d |
| S1770 | Permanent Bridge at Site | 50.0d | 722.1d |
| **Building & Camp Areas** | | 85.0d | 1005.1d |
| S1685 | Grubbing (167 acre) | 34.0d | 494.1d |
| S1690 | Earthworks Building Areas Including Roads & Locations for Water &... | 31.0d | 494.1d |
| S1695 | Gravel Surfacing (12 in./46,000 CY) | 58.0d | 1010.1d |
| S1700 | Site Drainage | 20.0d | 1005.1d |
| S1705 | Sports Fields | 20.0d | 1036.1d |
| S1710 | Fencing Building All Areas (15,666 LF) | 15.0d | 1010.1d |
| **Air Strip** | | 136.0d | 935.1d |
| S1730 | Grubbing (160 Acres) | 32.0d | 961.1d |
| S1735 | Earthworks (450,000 CY) | 75.0d | 935.1d |
| S1740 | Gravel Surfacing (24,000 CY) | 40.0d | 935.1d |
| S1745 | Concrete Paving | 24.0d | 935.1d |
| S1750 | Ancillaries (Lights, Radar, etc.) | 15.0d | 935.1d |
| S1755 | Demobilization | 15.0d | 935.1d |
| S1760 | Building, Camp & Airstrip Construction Complete | 0.0d | 935.1d |

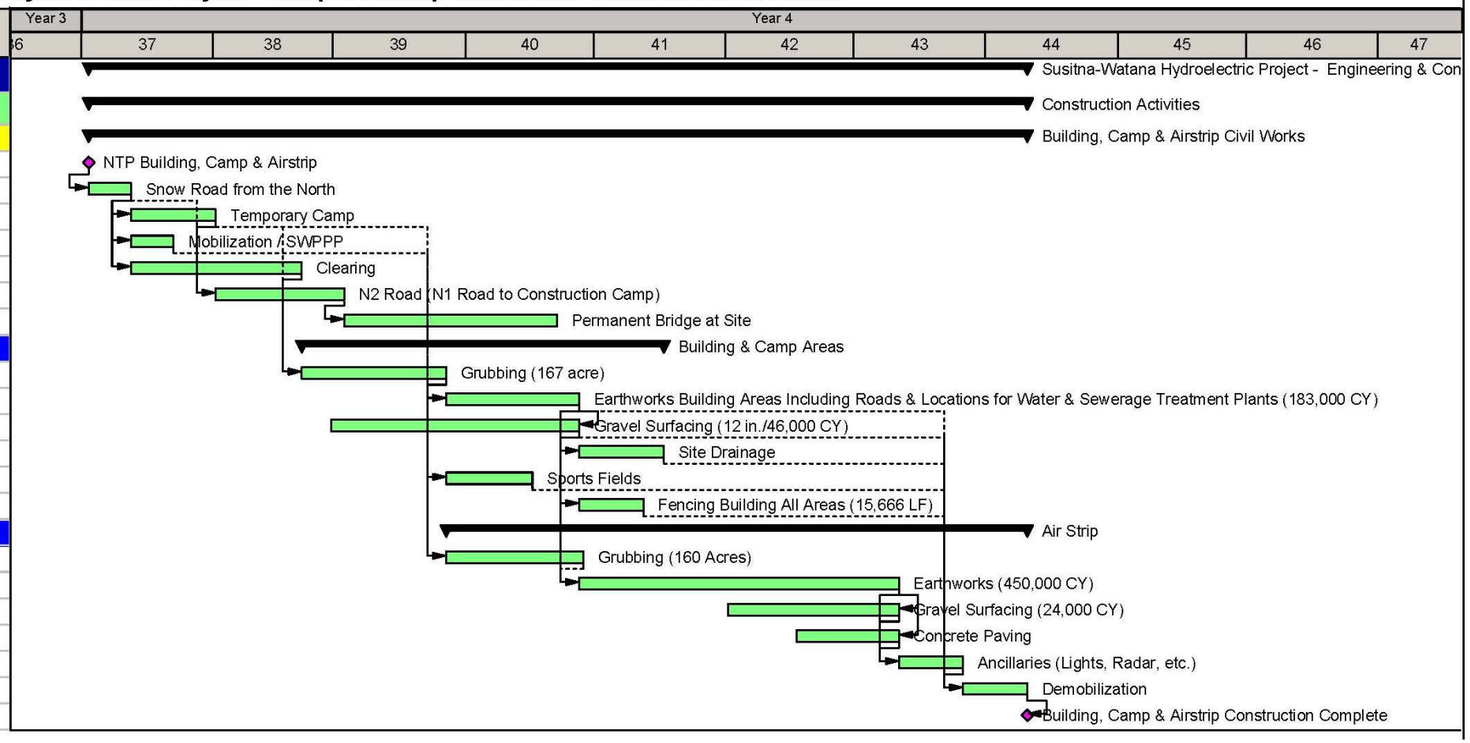



**Figure 14.1-4. Camp and Airstrip Civil Works Construction Schedule**

### 14.1.3.2. Camp and Airstrip Buildings Schedule

**Susitna-Watana Hydroelectric Project - Camp & Airstrip Buildings Construction Schedule**

| Activity ID | Activity Name | Original Duration | Total Float |
|---|---|---|---|
| | Susitna-Watana Hydroelectric Project - Engineerin... | 457.0d | 0.0d |
| | Construction Activities | 457.0d | 0.0d |
| | Camp Construction | 457.0d | 0.0d |
| S1804 | NTP Camp Construction | 0.0d | 1.0d |
| S1805 | Factory Assembly of Prefab Units | 366.0d | 1.0d |
| S1806 | Move 250 Man Camp to Main Dam | 15.0d | 0.0d |
| S1810 | Construct Permanent Village | 45.0d | 0.0d |
| S1815 | Construct Contractor Camp | 90.0d | 0.0d |
| S1820 | Camp Construction Complete | 0.0d | 0.0d |

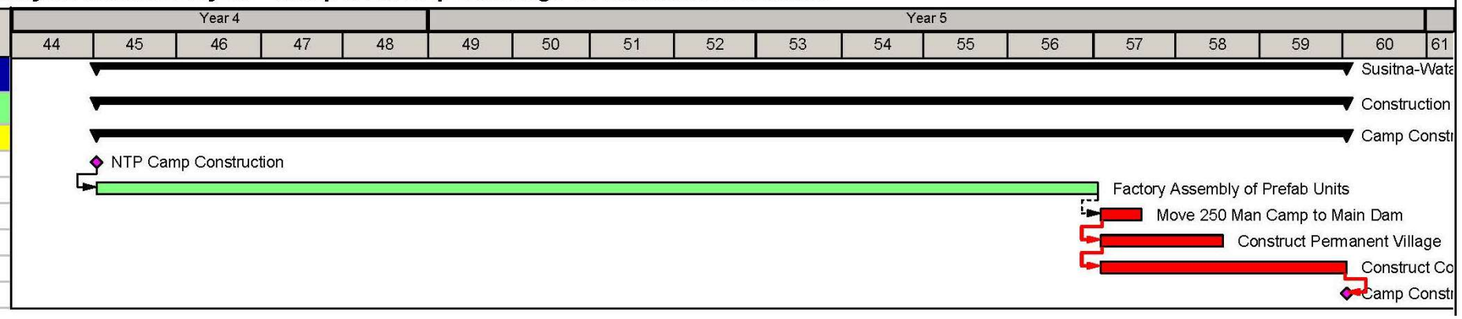
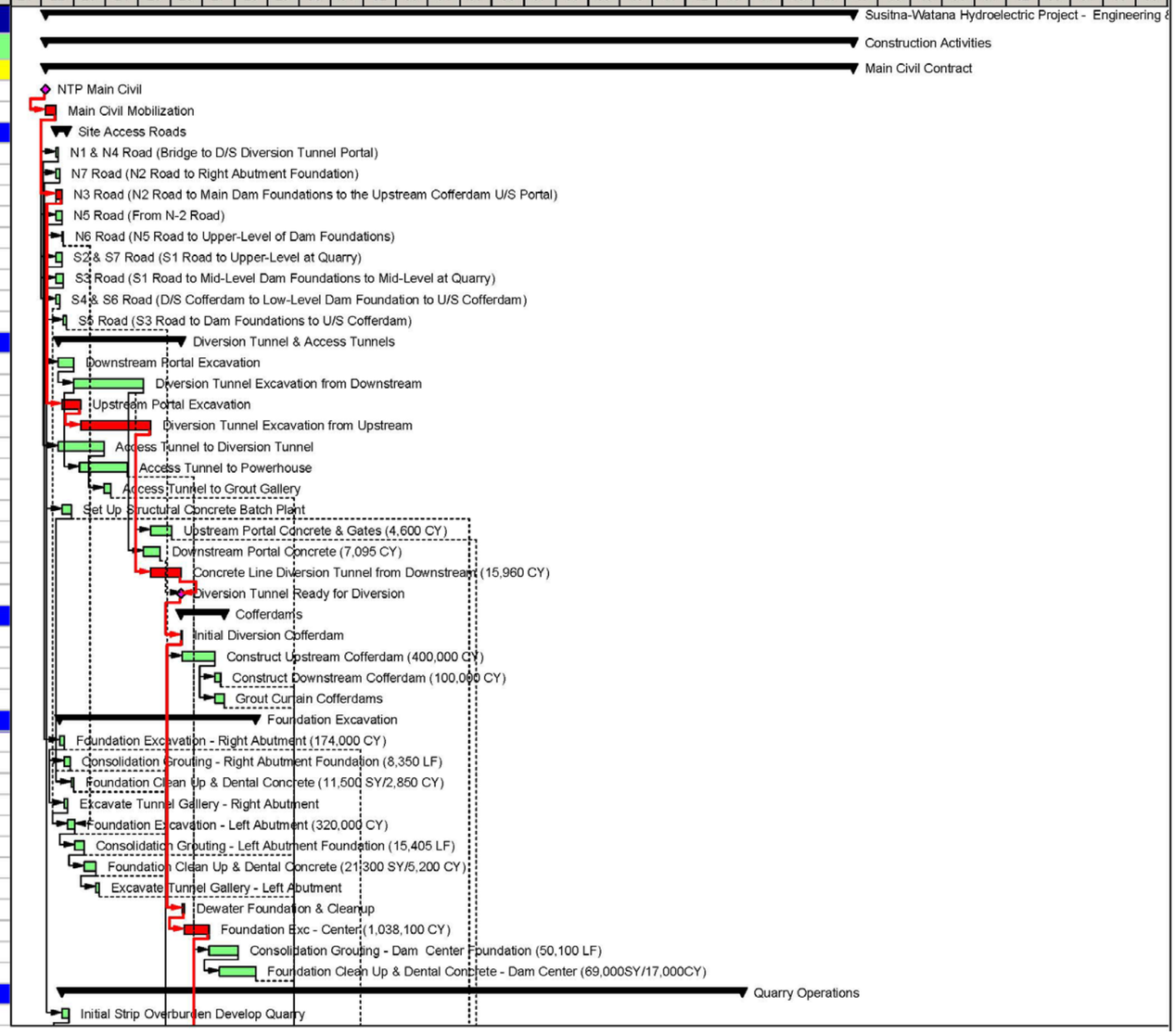



**Figure 14.1-5. Camp and Airstrip Building Construction Schedule**

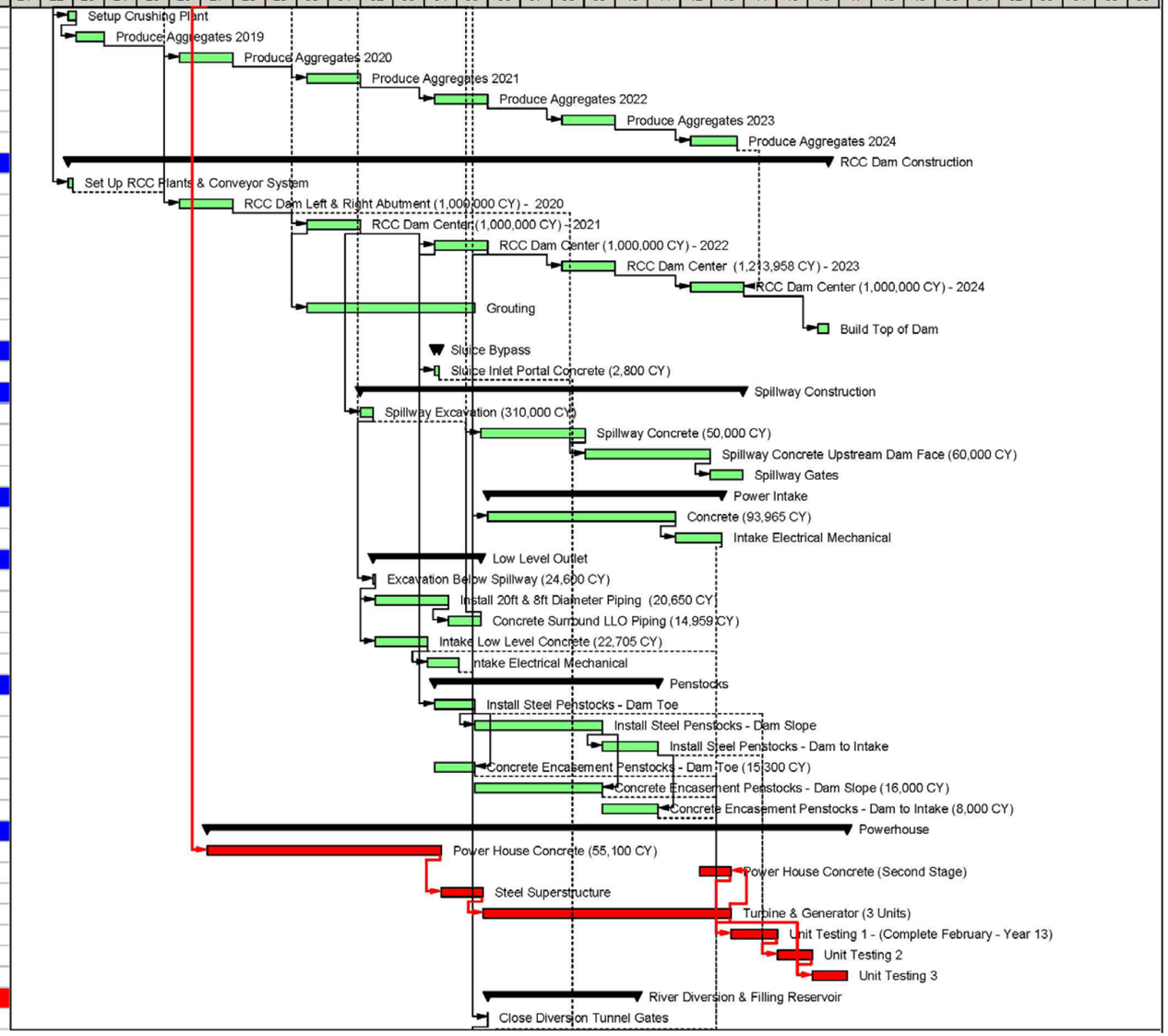
# Susitna-Watana Hydroelectric Project - Main Civil Construction Schedule

| Activity ID | Activity Name | Original Duration | Total Float |
|---|---|---|---|
| | Susitna-Watana Hydroelectric Project - Engineerin... | 1601.9d | 0.0d |
| | Construction Activities | 1601.9d | 0.0d |
| | Main Civil Contract | 1601.9d | 0.0d |
| S1244 | NTP Main Civil | 0.0d | 0.0d |
| S1245 | Main Civil Mobilization | 30.0d | 0.0d |
| | Site Access Roads | 28.0d | 570.1d |
| S1250 | N1 & N4 Road (Bridge to D/S Diversion Tunnel Portal) | 7.0d | 21.0d |
| S1255 | N7 Road (N2 Road to Right Abutment Foundation) | 8.0d | 87.1d |
| S1260 | N3 Road (N2 Road to Main Dam Foundations to the Upstream Coff... | 15.0d | 0.0d |
| S1265 | N5 Road (From N-2 Road) | 15.0d | 119.1d |
| S1270 | N6 Road (N5 Road to Upper-Level of Dam Foundations) | 5.0d | 119.1d |
| S1280 | S2 & S7 Road (S1 Road to Upper-Level at Quarry) | 15.0d | 0.1d |
| S1285 | S3 Road (S1 Road to Mid-Level Dam Foundations to Mid-Level at ... | 20.0d | 570.1d |
| S1290 | S4 & S6 Road (D/S Cofferdam to Low-Level Dam Foundation to U/... | 10.0d | 109.1d |
| S1295 | S5 Road (S3 Road to Dam Foundations to U/S Cofferdam) | 8.0d | 570.1d |
| | Diversion Tunnel & Access Tunnels | 348.0d | 1213.0d |
| S1300 | Downstream Portal Excavation | 40.0d | 21.0d |
| S1305 | Diversion Tunnel Excavation from Downstream | 200.0d | 21.0d |
| S1310 | Upstream Portal Excavation | 53.0d | 0.0d |
| S1315 | Diversion Tunnel Excavation from Upstream | 200.0d | 0.0d |
| S1320 | Access Tunnel to Diversion Tunnel | 128.0d | 1413.0d |
| S1325 | Access Tunnel to Powerhouse | 136.0d | 232.0d |
| S1335 | Access Tunnel to Grout Gallery | 20.0d | 1413.0d |
| S1340 | Set Up Structural Concrete Batch Plant | 28.0d | 92.1d |
| S1345 | Upstream Portal Concrete & Gates (4,600 CY) | 60.0d | 964.0d |
| S1350 | Downstream Portal Concrete (7,095 CY) | 47.0d | 59.0d |
| S1355 | Concrete Line Diversion Tunnel from Downstream (15,960 CY) | 85.0d | 0.0d |
| S1360 | Diversion Tunnel Ready for Diversion | 0.0d | 0.0d |
| | Cofferdams | 122.0d | 243.1d |
| S1365 | Initial Diversion Cofferdam | 2.0d | 0.0d |
| S1370 | Construct Upstream Cofferdam (400,000 CY) | 95.0d | 243.1d |
| S1375 | Construct Downstream Cofferdam (100,000 CY) | 15.0d | 253.1d |
| S1380 | Grout Curtain Cofferdams | 25.0d | 243.1d |
| | Foundation Excavation | 367.1d | 713.0d |
| S1390 | Foundation Excavation - Right Abutment (174,000 CY) | 13.0d | 85.3d |
| S1395 | Consolidation Grouting - Right Abutment Foundation (8,350 LF) | 15.0d | 96.3d |
| S1400 | Foundation Clean Up & Dental Concrete (11,500 SY/2,850 CY) | 5.0d | 90.3d |
| S1405 | Excavate Tunnel Gallery - Right Abutment | 10.0d | 85.3d |
| S1410 | Foundation Excavation - Left Abutment (320,000 CY) | 20.0d | 85.3d |
| S1415 | Consolidation Grouting - Left Abutment Foundation (15,405 LF) | 25.0d | 240.1d |
| S1420 | Foundation Clean Up & Dental Concrete (21,300 SY/5,200 CY) | 35.0d | 240.1d |
| S1425 | Excavate Tunnel Gallery - Left Abutment | 10.0d | 1443.0d |
| S1430 | Dewater Foundation & Cleanup | 7.0d | 0.0d |
| S1435 | Foundation Exc - Center (1,038,100 CY) | 70.0d | 0.0d |
| S1445 | Consolidation Grouting - Dam Center Foundation (50,100 LF) | 80.0d | 154.1d |
| S1450 | Foundation Clean Up & Dental Concrete - Dam Center (69,000SY/1... | 100.0d | 154.1d |
| | Quarry Operations | 1348.0d | 202.1d |
| S1455 | Initial Strip Overburden Develop Quarry | 20.0d | 0.1d |



## Susitna-Watana Hydroelectric Project - Main Civil Construction Schedule

| Activity ID | Activity Name | Original Duration | Total Float |
|---|---|---|---|
| S1460 | Setup Crushing Plant | 24.0d | 0.1d |
| S1465 | Produce Aggregates 2019 | 78.0d | 0.3d |
| S1470 | Produce Aggregates 2020 | 149.0d | 70.0d |
| S1475 | Produce Aggregates 2021 | 149.0d | 70.0d |
| S1480 | Produce Aggregates 2022 | 149.0d | 70.0d |
| S1485 | Produce Aggregates 2023 | 149.0d | 70.0d |
| S1490 | Produce Aggregates 2024 | 130.0d | 70.0d |
| **RCC Dam Construction** | | 882.0d | 51.0d |
| S1505 | Set Up RCC Plants & Conveyor System | 13.3d | 90.0d |
| S1510 | RCC Dam Left & Right Abutment (1,000,000 CY) - 2020 | 149.0d | 0.3d |
| S1515 | RCC Dam Center (1,000,000 CY) - 2021 | 149.0d | 0.3d |
| S1520 | RCC Dam Center (1,000,000 CY) - 2022 | 149.0d | 0.3d |
| S1525 | RCC Dam Center (1,213,958 CY) - 2023 | 149.0d | 51.0d |
| S1530 | RCC Dam Center (1,000,000 CY) - 2024 | 149.0d | 51.0d |
| S1545 | Grouting | 264.0d | 416.0d |
| S1555 | Build Top of Dam | 29.0d | 51.0d |
| **Sluice Bypass** | | 12.0d | 263.0d |
| S1330 | Sluice Inlet Portal Concrete (2,800 CY) | 12.0d | 263.0d |
| **Spillway Construction** | | 1092.0d | 299.0d |
| S1560 | Spillway Excavation (310,000 CY) | 35.0d | 139.0d |
| S1565 | Spillway Concrete (50,000 CY) | 300.0d | 299.0d |
| S1570 | Spillway Concrete Upstream Dam Face (60,000 CY) | 359.0d | 299.0d |
| S1575 | Spillway Gates | 90.0d | 299.0d |
| **Power Intake** | | 668.0d | 28.0d |
| S1580 | Concrete (93,965 CY) | 535.0d | 28.0d |
| S1585 | Intake Electrical Mechanical | 133.0d | 28.0d |
| **Low Level Outlet** | | 308.0d | 299.0d |
| S1590 | Excavation Below Spillway (24,600 CY) | 8.0d | 139.0d |
| S1595 | Install 20ft & 8ft Diameter Piping (20,650 CY) | 210.0d | 299.0d |
| S1665 | Concrete Surround LLO Piping (14,959 CY) | 90.0d | 299.0d |
| S1670 | Intake Low Level Concrete (22,705 CY) | 150.0d | 139.0d |
| S1675 | Intake Electrical Mechanical | 90.0d | 139.0d |
| **Penstocks** | | 639.0d | 209.0d |
| S1600 | Install Steel Penstocks - Dam Toe | 114.0d | 209.0d |
| S1610 | Install Steel Penstocks - Dam Slope | 365.0d | 209.0d |
| S1615 | Install Steel Penstocks - Dam to Intake | 160.0d | 209.0d |
| S1680 | Concrete Encasement Penstocks - Dam Toe (15,300 CY) | 114.0d | 734.0d |
| S1765 | Concrete Encasement Penstocks - Dam Slope (16,000 CY) | 365.0d | 369.0d |
| S1775 | Concrete Encasement Penstocks - Dam to Intake (8,000 CY) | 160.0d | 209.0d |
| **Powerhouse** | | 1300.0d | 0.0d |
| S1620 | Power House Concrete (55,100 CY) | 239.0d | 0.0d |
| S1625 | Power House Concrete (Second Stage) | 90.0d | 0.0d |
| S1630 | Steel Superstructure | 120.0d | 0.0d |
| S1635 | Turbine & Generator (3 Units) | 710.0d | 0.0d |
| S1640 | Unit Testing 1 - (Complete February - Year 13) | 130.0d | 0.0d |
| S1645 | Unit Testing 2 | 100.0d | 0.0d |
| S1650 | Unit Testing 3 | 100.0d | 0.0d |
| **River Diversion & Filling Reservoir** | | 428.0d | 268.0d |
| S17[illegible] | Close Diversion Tunnel Gates | 1.0d | 57.0d |



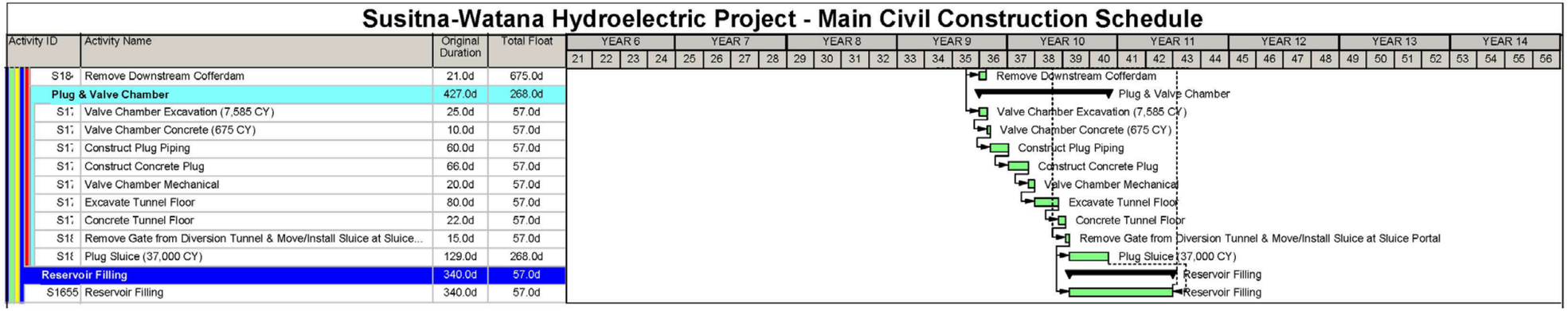



**Figure 14.1-6. Main Civil Construction Schedule**

## 14.2. Construction Schedule Derivation

### 14.2.1. General

Preliminary project schedules have been developed first for the complete project engineering and construction works – beginning with the site investigation and adit construction – and included in Appendix B11; and, second for the various construction packages (except transmission) shown above using the shortest reasonable time based on knowledgeable, experienced, and qualified U.S.-based contractors using high efficiency equipment and working methods.

The schedules can be regarded as aggressive, particularly in the earliest stages of construction. The construction of access to the site is critical to the current schedule. Access to the dam has been scheduled by pioneering to the site as soon as possible – along the line of the access road – with the conversion to permanent access road following. If this access cannot be completed, the overall schedule will be delayed.

The construction sequence was scheduled initially based on the expected date of FERC license issuance. The schedule for engineering required to facilitate construction was developed subsequently. The feasibility level construction schedule was developed based on the current concept design, and based on a logical work flow and interrelation among activities.

The following assumptions have been used to develop the construction schedule:

- The time required for execution of each activity was based on expected production rates.
- Activities start and finish dates reflect the “early start and finish” dates as that is the standard for Primavera until an activity is given an “actual start and finish” date.
- Seven-day work week.
- Surface work is based on two 10-hour shifts per day.
- Underground construction based on 24-hour per day production.
- Regional public holidays will be observed.
- Scheduling of electrical/mechanical equipment supply and installation is based on supply and installation times observed for similar types of equipment installed at similar dam and power house projects.
- The supply chain, via barges from the Lower 48, the Alaska Railroad, and the project access road, is not a constraint, and logistics will always be organized to support the required construction activities.

Traditional analysis was performed before calculating the durations based on planned and expected resources. The analysis compared the derivation of the logic associated with each task, and the establishment of links and precedence.

The tasks and links have been entered into Primavera P6 scheduling software and a Gantt chart derived, together with a critical path.

### 14.2.2. Potential Early Works

The road contemplated for access to the site has no use other than for construction (and operation) of the works. As noted, because of this sole use, the project to be licensed by FERC includes the access route, and (if Gold Creek or Chulitna road route is chosen) the associated railroad offloading yard. As noted, the inclusion of the access within the project subjects it to prohibition of construction before the FERC license is granted, and all associated permits and design reviews are complete. In other circumstances, the access would normally be constructed in advance of the main works so that the main project works could be implemented as soon as the license (and associated permits) was granted.

Although the linkage between the project works and the licensing has been removed for the reasons stated earlier, it is recognized that the schedule cannot be shortened if no works on site are commenced until the access road is complete. It is thus beneficial for construction works at the main site to begin as soon as possible, and the project team has considered the logic for, early access by "Rolligon" It must be noted, however, that although this storing of materials and plant has been included in the schedule, as described in the following paragraph, the implementation of such prepositioning might still be classed as "*construction*" by regulatory authorities and prudent scheduling would require that such activity not be commenced until the license is issued and the associated permits obtained.

It has been assumed that for the preparation of the camp civil works - and the preliminary grading of the airstrip - Rolligons (or snow CAT train) access will be used to transport plant and materials to the site before the road construction has reached the dam site. "Rolligon" is a generic name for a very low ground pressure vehicle used to transport equipment and supplies over snow covered tundra, such as the North Slope, as shown in Figure 14.2-1.

**Figure 14.2-1. Rolligon – Low Ground Pressure Vehicle**

It is also possible that, while the access road is under construction, such low ground pressure vehicles could convey tunneling equipment, excavation equipment, camp facilities, general plant, fuel and supplies, etc., from the north over the route of the Denali access so that critical tasks associated with the Main Civil construction contract – such as the diversion tunnel and quarry development – could also commence as early as possible.

This option has not been included in the schedule, but can be investigated further when a detailed procurement strategy has been finalized and the economic viability of this type of mobilization can thus be properly assessed.

For the Main Civil Contract works, the scale of the operation required to mobilize equipment, material and personnel to the project site means that importing everything to the site before the access road is completed, using this technique, is effectively impractical – or at the least so expensive as to be uneconomic.

### 14.2.3. Schedule Notes

#### *14.2.3.1. General*

The schedule indicates the anticipated dates for generating unit commissioning and project completion.

Following the notice to proceed with detailed site investigation, and assuming that the license and various permits are received in a timely manner (with regard to the current schedule), the total time for completion has been estimated as ten years and four months to the provision of first power from Unit 1 (i.e., completion of testing of Unit 1), followed by an additional seven months to bring the other two units on line. It should be noted that the extent to which full power is

drawn from each unit will determine the remaining time for reservoir filling and thus the time that the final load rejection and heat tests can be performed on all the units at full load.

Considering only the construction phase, the total time from the commencement of construction work (on the access) to the provision of first power from Unit 1 is about 7.5 years.

The critical path of the Engineering and Construction Schedule can be seen on the following page in Figure 14.2-2.

The critical path of the **engineering activities** is defined by the following tasks:

- Site Investigation
  - Contract Documents
  - Bidding
  - Bid Adjudication
  - Award
  - Investigation – Summer Season and Initial Report
  - Investigation – Winter Season
  - Testing /Report Writing
- Permanent Access Road Engineering
  - Engineering and Contract Documents
  - Bidding
  - Bid Adjudication
  - Award
- Camp and Airstrip Buildings Engineering
  - Bidding
  - Bid Adjudication
  - Award

## Susitna-Watana Hydroelectric Project - Critical Path Construction Schedule

| Activity ID | Activity Name | Original Duration | Total Float |
|---|---|---|---|
| | Susitna-Watana Hydroelectric Project - Engineerin... | 2573.9d | 0.0d |
| | Engineering Activities | 606.0d | 0.0d |
| A0000 | Engineering NTP (September - Year 1) | 0.0d | 0.0d |
| | Site Investigation | 335.0d | 0.0d |
| A1000 | Contract Documents | 78.0d | 0.0d |
| A1010 | Bidding | 60.0d | 0.0d |
| A1020 | Bid Adjudication | 30.0d | 0.0d |
| A1030 | Award | 1.0d | 0.0d |
| A1050 | Investigation - Summer Season & Initial Report | 109.0d | 0.0d |
| A1051 | Investigation - Winter Season | 57.0d | 0.0d |
| A1060 | Testing/Report Writing | 90.0d | 0.0d |
| | Permanent Access Road Engineering | 271.0d | 0.0d |
| A1130 | Engineering & Contract Documents (PAR) | 180.0d | 0.0d |
| A1140 | Bidding | 45.0d | 0.0d |
| A1150 | Bid Adjudication | 45.0d | 0.0d |
| A1160 | Award | 1.0d | 0.0d |
| | Construction Activities | 2082.9d | 0.0d |
| S1605 | Construction Complete | 0.0d | 0.0d |
| | Permanent Access Road | 609.0d | 0.0d |
| S1084 | Permanent Access Road NTP | 0.0d | 0.0d |
| S1095 | Clearing & Grubbing | 125.0d | 0.0d |
| S1105 | Permanent Access Road - Excavation Common (1st Season) | 146.0d | 0.0d |
| S1115 | Permanent Access Road - Excavation Rock (1st Season) | 146.0d | 0.0d |
| S1120 | Permanent Access Road - Embankment (1st Season) | 146.0d | 0.0d |
| S1121 | Winter Shutdown | 212.0d | 0.0d |
| S1190 | Permanent Access Road Long Span Bridge (MP 21.6) | 45.0d | 0.0d |
| S1195 | Permanent Access Road Long Span Bridge (MP 26) | 40.0d | 0.0d |
| S1200 | Permanent Access Road Long Span Bridge (MP 43) | 40.0d | 0.0d |
| | Camp Construction | 90.0d | 0.0d |
| S1806 | Move 250 Man Camp to Main Dam | 15.0d | 0.0d |
| S1810 | Construct Permanent Village | 45.0d | 0.0d |
| S1815 | Construct Contractor Camp | 90.0d | 0.0d |
| S1820 | Camp Construction Complete | 0.0d | 0.0d |
| | Main Civil Contract | 1601.9d | 0.0d |
| S1244 | NTP Main Civil | 0.0d | 0.0d |
| S1245 | Main Civil Mobilization | 30.0d | 0.0d |
| | Site Access Roads | 15.0d | 0.0d |
| S1260 | N3 Road (N2 Road to Main Dam Foundations to the Upstream Coff... | 15.0d | 0.0d |
| | Diversion Tunnel & Access Tunnels | 338.0d | 0.0d |
| S1310 | Upstream Portal Excavation | 53.0d | 0.0d |
| S1315 | Diversion Tunnel Excavation from Upstream | 200.0d | 0.0d |
| S1355 | Concrete Line Diversion Tunnel from Downstream (15,960 CY) | 85.0d | 0.0d |
| S1360 | Diversion Tunnel Ready for Diversion | 0.0d | 0.0d |
| | Cofferdams | 2.0d | 0.0d |
| S1365 | Initial Diversion Cofferdam | 2.0d | 0.0d |
| | Foundation Excavation | 77.0d | 0.0d |
| S1430 | Dewater Foundation & Cleanup | 7.0d | 0.0d |
| S1435 | Foundation Exc - Center (1,038,100 CY) | 70.0d | 0.0d |
| | Powerhouse | 1300.0d | 0.0d |
| S1620 | Power House Concrete (55,100 CY) | 239.0d | 0.0d |
| S1625 | Power House Concrete (Second Stage) | 90.0d | 0.0d |
| S1630 | Steel Superstructure | 120.0d | 0.0d |
| S1635 | Turbine & Generator (3 Units) | 710.0d | 0.0d |
| S1640 | Unit Testing 1 - (Complete February - Year 13) | 130.0d | 0.0d |
| S1645 | Unit Testing 2 | 100.0d | 0.0d |
| S1650 | Unit Testing 3 | 100.0d | 0.0d |

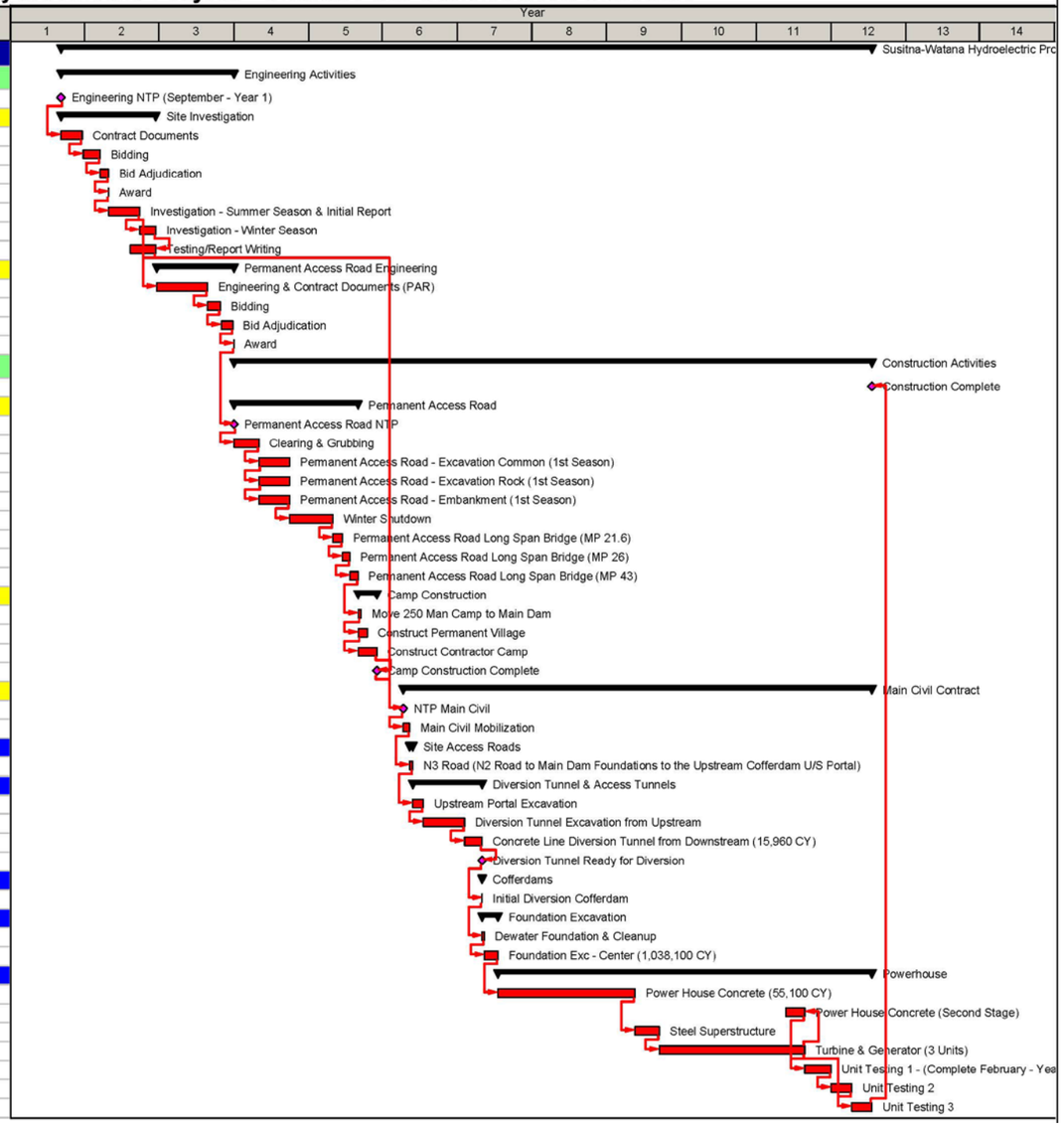



**Figure 14.2-2. Susitna-Watana Engineering and Construction Schedule: Critical Path**

The critical path of the **construction activities** is formed by the following tasks:

- Permanent Road Access
  - Notice to Proceed
  - Clearing and Grubbing
  - Excavation Common – (1st Season)
  - Excavation Rock – (1st Season)
  - Excavation Embankment – (1st Season)
  - Winter Shutdown
  - Long Span Bridge (mile post [MP] 21.6)
  - Long Span Bridge (MP 26)
  - Long Span Bridge (MP 43)
- Camp Construction
  - Move 250 Labor Camp
  - Construct Permanent Village
  - Construct Contractor Camp
  - Camp Construction Complete

  It should be noted that the critical path does not follow the off-site factory assembly of the units that are to be transported to the site, but follows the on-site construction.
- Main Civil Contract
  - Notice to Proceed
  - Main Civil Mobilization
  - Site Access Roads
    - N3 Road (N2 Road to Main Dam Foundations to the upstream Cofferdam)
  - Diversion Tunnel and Access Tunnels
  - Upstream Portal Excavation
  - Diversion Tunnel Excavation from Upstream
  - Concrete Line Diversion Tunnel from Downstream

- Diversion Tunnel Ready for Diversion
- Cofferdams
  - Initial Diversion Cofferdam
- Foundation Excavation
  - Dewater Foundation and Cleanup
  - Foundation Excavation – center portion of the dam
- Powerhouse
  - Powerhouse Concrete
  - Steel Superstructure
  - Turbines and Generators
  - Units 1, 2 and 3 Testing

It is evident that the earliest possible commencement of the diversion tunnels construction is vital to achieving the fastest possible completion of the Project, and hence the proposal for pioneering of an access road, and the recommendation to consider the advantages of a CAT train/Rolligon associated with the Main Civil Contract works for limited movement of materials and equipment. This could allow critical work to begin on site as soon as possible such as site access roads and the Diversion Tunnel and Access Tunnels.

The use of the airstrip at Stephan Lake (in conjunction with a temporary access road to the road and transmission corridor) during the first years of construction may allow some schedule reductions. However, the temporary road is outside of the road corridor and project boundary and would be subject to extra study and permitting.

#### *14.2.3.2. RCC Production*

The RCC dam volume (5.215 million cubic yards) will be one of the largest volumes of RCC dam constructed to date. The rate of placement of RCC has been assumed (on average) as 200,000 cubic yards per month over five seasons (25 months) of placement.

Placement rates for RCC are very much dependent on the following factors (among others):

- A well planned and properly developed quarry;
- The amount of sorting required in the quarry;

- The efficiency and capacity of the plant in the quarry: drilling, loading of holes, loading on to trucks, quarry clean up;
- The provision and maintenance of appropriate haul roads;
- Efficient, reliable and high capacity trucks;
- The efficiency of the mixing and RCC transport plant;
- The efficiency and reliability of the cement and fly ash delivery;
- The efficiency and capacity of the spreading and rolling plant;
- The overall planning of the work to minimize constricted working areas; and,
- The adequacy of the plant maintenance arrangements.

Although high average placement rates can be achieved with large, high capacity, high efficiency, heavy dump trucks and loaders, the construction consistency required in achieving an average of 200,000 cubic yards per month (or more) demands a sophisticated RCC delivery methodology, including multiple RCC batch plants (allowing for peak capacities and for limiting the effect of any unplanned outages), a high capacity and reliable supply chain for cement and aggregates, enhanced and well maintained haul roads, a well planned and executed quarry operation, and high capacity (oversized and reliable) conveying systems.

#### *14.2.3.3. Summary of Important Activities*

A summary of the most important activities (or set of activities) is presented in Table 14.2-1 below, together with notes on the production and/or logic. A fundamental driving factor in the schedule is the necessity to "smooth" production and placement of RCC over as long a time as possible to ensure that the average rate of RCC production is reasonable (although it will still be one of the highest average production rates for such a dam):

**Table 14.2-1. Key Activity Durations**

| Activity | Duration (working days, except as noted) | Production Notes |
|---|---|---|
| Clearing: Railyard, Access Roads, Roads at Site, Airport, etc. | 526 | Clearing cannot be performed between 1st of April and the 15th of June (although construction activities can be carried out on areas previously cleared) because of migratory bird activity. With the exception of the rail yard work, for which an exception will be requested, all clearing activities will take place outside of the migratory window. |
| Pioneer Access road to site | 646 | To establish access to site, the first thrust of activity, after establishing an offloading facility at the railway, will be the creation of a narrow access road, sufficient for moving plant, fuel and materials to site for the initial construction. The standard of the road will be low, speed of construction being the most important aspect of the work. |

| Activity | Duration (working days, except as noted) | Production Notes |
|---|---|---|
| Diversion tunnel portal excavations | 261 | Both portals will commence immediately after access is available to site. |
| Diversion tunnel | 348 | The diversion tunnel will be excavated from both ends to minimize the construction time, followed by concrete lining from the downstream end. |
| Foundation preparation on the abutments | 77 | Overburden clearance and foundation excavation (including the lowest level grouting adits) on each abutment will commence at the same time as the diversion tunnel construction, to facilitate the early placement of RCC on the abutment sections of the dam. |
| Quarry preparation | 44 | Quarry preparation will be another early task, initiated as soon as possible and before the diversion tunnel is complete, so that sufficient aggregates can be produced for the first RCC placement on the right abutment which will occur before diversion. |
| Dam RCC placement on right and left abutments | 149 | RCC placement on the right and left abutment will occur during the first season of placement while the foundations are being cleaned and excavated in the river bed following diversion. RCC placement will also occur in the fifth season to topping off the two abutments. |
| Dam Center RCC placement | 596 | RCC placement for the Dam center will occur during the second season through the fifth season of placement to full height. |

The base schedule gives all anticipated dates in years from commencement of site investigation. It records the overall project completion expectation – but should be considered to be a schedule based on aggressive production rates with limited recognition of unplanned events. It should be understood that unforeseen circumstances and events beyond the control of the engineer, AEA, or contractor could cause delays beyond the anticipated dates indicated in the attached schedule. As more comprehensive information is available from upcoming site investigations, probabilistic analysis of the schedule is recommended.