Wainwright Wind-Diesel Conceptual Design Report

6 March 2015

This report prepared for

North Slope Borough

by

WHPacific

and

V3 Energy LLC

This report was written by Douglas Vaught, P.E. of V3 Energy, LLC under contract to WHPacific Solutions Group for development of wind power in the village of Wainwright, Alaska. This analysis is part of a wind energy design project for the North Slope Borough and funded by the Alaska Energy Authority.

Contents

Introduction

North Slope Borough is the electric utility for the City of Wainwright. In 2009 North Slope Borough contracted WHPacific to install met towers and perform wind resource assessment analyses in five Borough communities: Point Hope, Wainwright, Atqasuk, Kaktovik, and Anaktuvuk Pass (a wind resource assessment was previously completed by U.S. DOE for Point Lay). This was followed in 2011 with a contract to WHPacific to write feasibility studies for the villages of Point Hope, Point Lay, and Wainwright. WHPacific subcontracted V3 Energy, LLC to assist with both efforts. In 2013 North Slope Borough contracted WHPacific Solutions Group (WHPSG) to complete the conceptual design phase of the project in anticipation of Alaska Energy Authority authorizing wind power design projects for the three communities.

WHPSG has contracted V3 Energy, LLC to re-evaluate the wind resource assessment and feasibility study for each community, update the power systems modeling with a selection of appropriate village-scale wind turbines, and perform preliminary economic analyses of the proposed projects. This conceptual design report for the village of Wainwright is a culmination of that effort.

Project Management

The North Slope Borough, Department of Public Works, has executive oversight of this project. North Slope Borough and the City of Wainwright wish to install wind turbines in Wainwright primarily to reduce diesel fuel consumption and save money, but also to:

- Reduce long-term dependence on outside sources of energy
- Reduce exposure to fuel price volatility
- Reduce air pollution resulting from reducing fossil fuel combustion
- Reduce possibility of spills from fuel transport & storage
- Reduce North Slope Borough's carbon footprint and its contribution to climate change.

Executive Summary

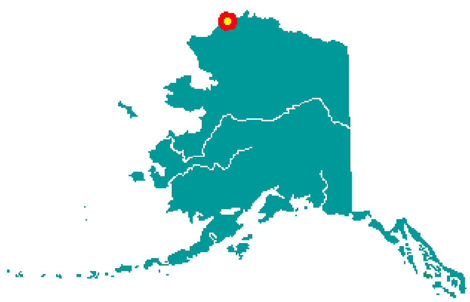
WHPacific Solutions Group and V3 Energy, LLC recommend the planned (2016 release) new 360 kW Northern Power System 360-39 wind turbine in a medium penetration mode for a Wainwright wind power project. This recommendation is based on Northern Power System's track record and support network in Alaska, the ability to achieve turbine commonality with all four Borough wind power project communities (Point Hope, Point Lay, Wainwright, and Kaktovik), and Northern Power System's factory technical support.

The recommended wind turbine site location is Site B near the landfill; chosen by the community in 2011 and in 2013 as their preferred site.

The reader is cautioned to note that this conceptual design report was prepared as an abbreviated or "light" version of a typical conceptual design. With that in mind, although turbine choice, site location, and wind power penetration goals are presented, discussed and/or recommended in this report, further conversation and collaboration with North Slope Borough project management, Olgoonik Corporation, and residents of the community of Wainwright is recommended before the project progresses to detailed design.

Wainwright

In 1826 the Wainwright Lagoon was named by Capt. F.W. Beechey for his officer, Lt. John Wainwright. An 1853 map indicates the name of the village as "Olrona." Its Inupiat name was "Olgoonik." The region around Wainwright was traditionally well-populated, though the present village was not established until 1904 when the Alaska Native Service built a school and instituted medical and other services. The site was reportedly chosen by the captain of the ship delivering school construction materials, because sea-ice conditions were favorable for landing. A post office was established in 1916, and a city was formed in 1962. Coal was mined at several nearby sites for village use; the closest was about seven miles away. Today though most houses are heated by fuel oil. A U.S. Air Force Distance Early Warning (DEW) Station was constructed nearby in the 1960's.



A federally-recognized tribe is located in the community, the Village of Wainwright. Most Wainwright inhabitants are Inupiat Eskimos who practice a subsistence lifestyle. Their ancestors were the Utukamiut (people of the Utukok River) and Kukmiut (people of the Kuk River).

According to Census 2010, there were 179 housing units in the community and 147 were occupied. Wainwright's population of 556 people is 90 percent Alaska Native, 8 percent Caucasian, and 2 percent Hispanic, multi-racial or other.

The North Slope Borough provides all utilities in Wainwright. Water is obtained from Merekruak Lake three miles northeast of the community, treated and stored in tanks. Water is hauled from this point or delivered to household tanks by truck. Hauling services are provided by the borough. The majority of homes have running water for the kitchen. Electricity is provided by North Slope Borough. There is one school located in the community, attended by 149 students. Local hospitals or health clinics include Wainwright Health Clinic. Emergency Services have coastal and air access. Emergency service is provided by 911 Telephone Service volunteers and a health aide. Auxiliary health care is provided by Wainwright Volunteer Fire Dept. (907-763-2728).

Economic opportunities in Wainwright are influenced by its proximity to Barrow and the fact that it is one of the older, more established villages. Most of the year-round positions are in borough services. The sale of local Eskimo arts and crafts supplements income. Bowhead and beluga whale, seal, walrus, caribou, polar bear, birds, and fish are harvested for subsistence.

Note that information regarding Wainwright is drawn from the Alaska Community Database Community

Information Summaries (CIS) which can be found at http://www.dced.state.ak.us/dca/commdb/CIS.cfm. Regarding the American Community Survey information, MOE refers to *margin of error*.

Topographic map of Wainwright

Google Earth image of Wainwright

Wind Resource Assessment

The wind resource measured in Wainwright is good, at wind power class 4. In addition to strong average wind speeds and wind power density, the site experiences highly directional prevailing winds, low turbulence and calculations indicate low extreme wind speed probability.

A 34 meter met tower, erected to 30 meters, was installed in June 2009 approximately 500 meters (1,600 ft.) northeast of the village of Wainwright, near the Chukchi Sea shoreline. This site is relatively near the power plant and well exposed to winter winds with no upwind obstructions. The met tower was removed in July 2010.

Met tower data synopsis

Data dates	June 19, 2009 to July 16, 2010 (13 months)
Wind power class	High 4 (good)
Power density mean, 30 m	413 W/m² (QC'd data); 392 W/m² (with synthetic data)
Wind speed mean, 30 m	7.05 m/s (QC'd data); 6.96 m/s (with synthetic data)
Max. 10-min wind speed average	22.2 m/s
Maximum wind gust	25.8 m/s (Feb. 2010)
Weibull distribution parameters	k = 2.2, c = 7.97 m/s
Wind shear power law exponent	0.137 (moderately low)
Roughness class	1.51 (crops)
IEC 61400-1, 3rd ed. classification	Class III-c (lowest defined and most common)
Turbulence intensity, mean	0.072 (at 15 m/s)
Calm wind frequency	16% (<3.5 m/s)

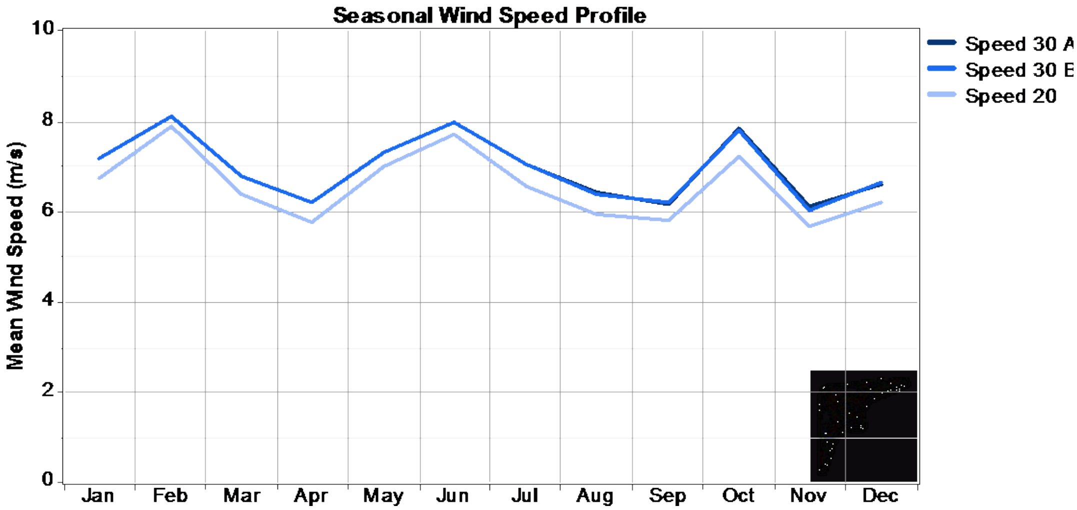
Data Recovery

Data recovery in Wainwright was mostly acceptable, with 75 to 80 percent data recovery of the anemometers and wind vane. Note that data recovery in December and January was particularly poor, apparently due to frost conditions during this deep cold period of mid-winter. It is possible or even likely that some data flagged as icing in December 2009 and January 2010 in particular may in fact be calm winds. If so, annual wind speeds may be lower than noted in the preceding table. With reference to Wainwright 1999 through 2004 airport ASOS data (8 meter sensor level) analyzed by Alaska Energy Authority, annual average wind speed of approximately 5.6 m/s was calculated. When scaled to 30 meters with a power law exponent of 0.14, result is 6.73 m/s, which is less than the 6.96 m/s predicted from filtered and gap-filled met tower data. Either way, the Wainwright wind resource classifies as Class 4 (good).

Wind Speed

Wind data collected from the met tower, from the perspective of both mean wind speed and mean power density, indicates an excellent wind resource. The cold arctic temperatures of Wainwright contributed to the high wind power density. It is problematic, however, analyzing wind data with significant concentrated data loss, such as occurred in Wainwright during November through January, then again in March. To correct this problem, synthetic data was inserted in the data gaps to create a more realistic wind speed data profile. To be sure, long segments of synthetic data introduce uncertainty to the data set, but missing data does as well. To overcome this uncertainty, improved data collection with heated sensors would be necessary. But, considering the robust wind resource measured and noting the long-term airport AWOS data confirming the wind resource measured by the met tower, continuing a wind study with heated sensors is not truly necessary in Wainwright.

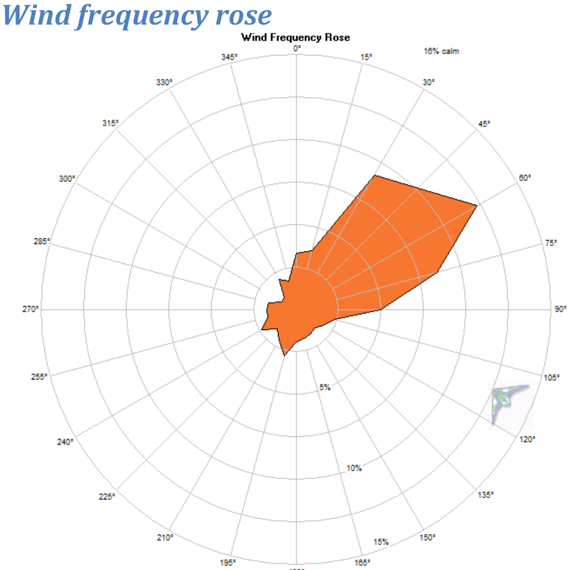
Wind speed profile



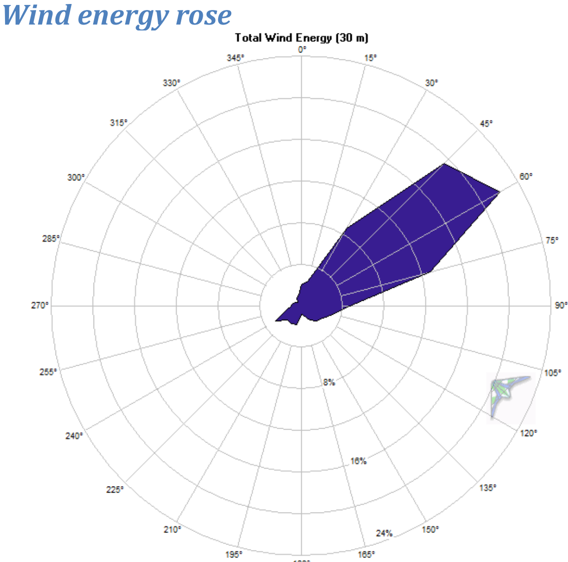
Wind Rose

Wind frequency rose data indicates highly directional winds from northeast to east-northeast. Power density rose data (representing the power in the wind) indicates power winds are strongly directional, from 030°T to 070°T and to a much lesser extent from 240°T. Calm frequency (percent of time that winds at 30 meter level are less than 3.5 m/s) was 16 percent during the met tower test period.

Wind frequency rose



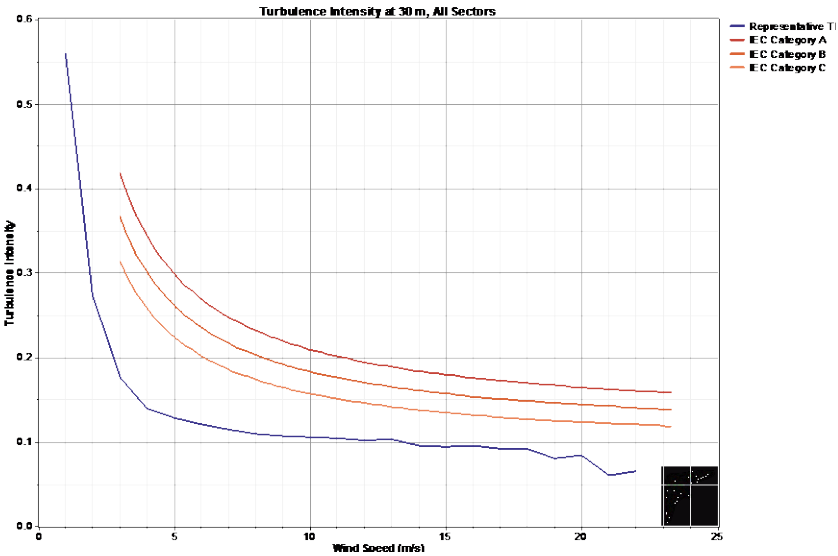
Wind energy rose



Turbulence Intensity

Turbulence intensity at the Wainwright test site is well within acceptable standards with an IEC 61400-1, 3rd edition (2005) classification of turbulence category C, which is the lowest defined. Mean turbulence intensity at 15 m/s is 0.072.

Turbulence graph



Extreme Winds

Although thirteen months of data is minimal for calculation of extreme wind probability, use of a modified Gumbel distribution analysis, based on monthly maximum winds vice annual maximum winds, yields reasonably good results. Extreme wind analysis indicates a highly desirable situation in Wainwright: moderately high mean wind speeds combined with low extreme wind speed probabilities. This may be explained by particular climactic aspects of Wainwright which include prominent coastal exposure, offshore wind conditions, and due to the extreme northerly latitude, lack of exposure to Gulf of Alaska storm winds.

Industry standard reference of extreme wind is the 50 year, 10-minute average probable wind speed, referred to as V_{ref}. For Wainwright, this calculates to 29.6 m/s, below the threshold of International Electrotechnical Commission (IEC) 61400-1, 3rd edition criteria (of 37.5 m/s) for a Class III site. Note that Class III extreme wind classification is the lowest defined and all wind turbines are designed for this wind regime.

Wainwright met tower Gumbel distribution of extreme wind

Period (years)	V_{ref} (m/s)	Gust (m/s)	IEC 61400-1, 3rd ed. Class	IEC 61400-1, 3rd ed. V_{ref}, m/s
2	22.2	26.7	I	50.0
10	25.9	31.2	II	42.5
15	26.9	32.3	III	37.5
30	28.5	34.2	S	designer-specified
50	29.6	35.6		

100	31.2	37.5
average gust factor:	1.20	

The complete V3 Energy, LLC wind resource assessment report of Wainwright is forwarded with this conceptual design report.

Cold Climate Considerations of Wind Power

Wainwright's harsh climate conditions is an important consideration should wind power be developed in the community. The principal challenges with respect to turbine selection and subsequent operation is severe cold and icing. Many wind turbines in standard configuration are designed for a lower operating temperature limit of -20° C (-4° F), which clearly would not be suitable for Wainwright, nor anywhere else in Alaska. A number of wind turbine manufacturers offer their turbine in an "arctic" configuration which includes verification that structural and other system critical metal components are fatigue tested for severe cold capability. In addition, arctic-rated turbines are fitted with insulation and heaters in the nacelle and power electronics space to ensure proper operating temperatures. With an arctic rating, the lower temperature operating limit generally extends to -40° C (-40° F). On occasion during winter Wainwright may experience temperatures colder than -40° C which would signal the wind turbines to stop. Temperatures below -40° C are relatively infrequent however and when they do occur, are generally accompanied by lighter winds.

A second aspect of concern regarding Wainwright's arctic climate is icing conditions. Atmospheric icing is a complex phenomenon characterized by astonishing variability and diversity of forms, density, and tenacity of frozen precipitation, some of which is harmless to wind turbine operations and others highly problematic. Although highly complex, with respect to wind turbines and aircraft five types of icing are recognized: clear ice, rime ice, mixed ice, frost ice, and SLD ice (www.Wikipedia.org/wiki/icing_conditions).

- Clear ice is often clear and smooth. Super-cooled water droplets, or freezing rain, strike a surface but do not freeze instantly. Forming mostly along the stagnation point on an airfoil, it generally conforms to the shape of the airfoil.
- Rime ice is rough and opaque, formed by super-cooled drops rapidly freezing on impact. Often "horns" or protrusions are formed and project into the airflow.
- Mixed ice is a combination of clear and rime ice.
- Frost ice is the result of water freezing on unprotected surfaces. It often forms behind deicing boots or heated leading edges of an airfoil and has been a factor airplane crashes.
- SLD ice refers to ice formed in super-cooled large droplet (SLD) conditions. It is similar to clear ice, but because droplet size is large, it often extends to unprotected parts of a wind turbine (or aircraft) and forms large ice shapes faster than normal icing conditions.

Wind Project Sites

North Slope Borough requested that two wind turbine sites be identified in Wainwright. On July 6, 2011, Ross Klooster of WHPacific and Max Ahgeak of North Slope Borough Public Works Dept. traveled to Wainwright and met with Village of Wainwright and Olgoonik Corporation representatives to discuss the wind power project and to identify the two sites. This was accomplished by reviewing maps and ownership records and then driving and walking to a number of locations near the village to assess suitability for construction and operation of wind turbines. Two sites on Olgoonik Corporation land were chosen, identified as Site A and Site B in the Google Earth image below.

Wainwright site options, Google Earth image

Site A

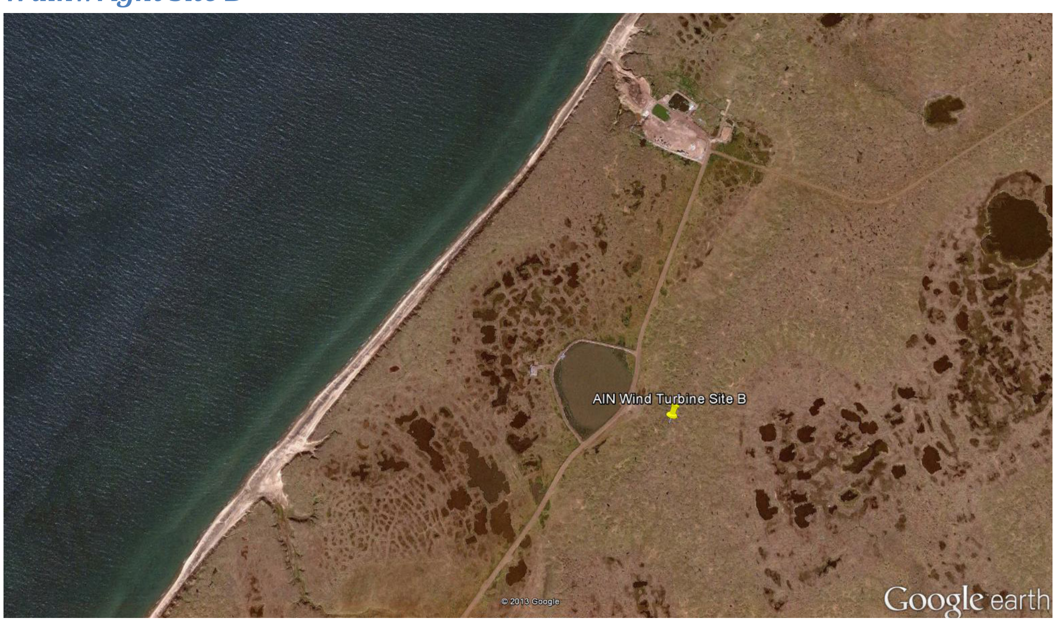
Site A is a very well exposed area immediately northeast of the village and just beyond the protective snow fences on Wainwright's north side. It is an expansive location with plenty of room for a multi-turbine array, is relatively dry and hence likely to have stable permafrost for foundation construction, and would require minimal distribution line construction to connect turbines to the power plant. Unfortunately though, a 2011 FAA notice of presumed hazard (refer to Appendix A) for the site limits turbine construction to 148 ft. above ground level, without further review. With respect to the turbines options considered in this report, 30 meter towers may be the highest possible at Site A.

Wainwright Site A

Site B

Site B shares the same apparent physical characteristics as Site A and hence it is a quite suitable location for wind turbines. A key advantage of Site B over Site A is that construction height is essentially unrestricted from an FAA perspective (refer to a 2011 FAA Determination of No Hazard letter in Appendix B). The primary disadvantage of this site is its distance from Wainwright, necessitating an additional 2.4 km (1.5 mile) distribution line construction. But, turbines could be placed very near the access road, resulting in lower access road construction costs than at Site A. To be addressed in the following section though, Site B presents avian concerns not found at Site A.

Wainwright Site B



Wainwright wind turbine site options table

Site	Advantages	Disadvantages
A	• Olgoonik Corp. land • Site is large enough to accommodate several or more turbines and has sufficient room for future expansion • Relatively dry site; likely good permafrost geotech conditions	• Turbines will be in view and possible auditory range of residents on the north side of the village • 275 to 375 meter (900 to 1,200 ft) access road and distribution line construction required (depending on access direction) • FAA determination of Notice of Presumed Hazard (NPH) for turbines exceeding 148 ft AGL
B	• Olgoonik Corp. land • Site is large enough to accommodate several turbines and has sufficient room for future expansion • Location is relatively far from the village and unlikely to present aesthetic and noise complaints • Relatively dry site; likely good permafrost geotech conditions • FAA Determination of No Hazard to Air Navigation for turbines up to 195 ft AGL (possibly higher) • Site near existing road to landfill	• 2.4 km (1.5 miles) of new distribution line required • More expensive to develop than Site A • Potential avian concerns

Other Site Options

Other than Sites A and B, something in-between, or a minor variation of these two options, realistically there are no other wind turbine site options for Wainwright. Terrain east of the village is possible, but the airport constrains the nearer possibilities and, importantly, a road does not exist in that direction, hence development costs would be extremely high. Terrain to the southwest is marginal due to its peninsular nature between Wainwright Inlet and the Bering Sea. Plus, airport runway alignment precludes this consideration. West of Wainwright is the Bering Sea and hence obviously unsuitable for turbine construction.

Recommended Site Option

Through discussion with community residents and representatives of Wainwright in 2011 and again in 2013, the residents of Wainwright indicated their preference for Site B as the preferred option for a wind power project. WHPacific Solutions Group and V3 Energy, LLC concur with this preference, conclusions of the ABR, Inc. avian study notwithstanding, but which may require further discussion and consultation.

Wildlife/Avian Study

North Slope Borough commissioned ABR, Inc. of Fairbanks, Alaska to summarize the biological resources of Point Hope, Point Lay and Wainwright, including both plant and animal species to support the wind project development effort. ABR's work is documented in a report titled: *Site Characterization and Avian Field Study for the Proposed Community-Scale Wind Project in Northern Alaska*.

The ABR study states: The objectives of the Site Characterization Study (SCS) were to: (1) compile and review existing landcover map products to prepare generalized landcover maps; (2) characterize the biological resources present; (3) summarize the potential exposure of biological (particularly avian) resources to impacts; and (4) identify field studies to identify site-specific risks to biological resources (particularly birds). The objectives of the field studies conducted in 2013 were to: (1) describe temporal and spatial patterns of habitat use of all birds within and near proposed wind-sites; and (2) provide a summary of the exposure of focal species to collision risk at each proposed site. This final report summarizes the SCS and field data to describe the relative exposure of the focal species to the proposed wind-energy development at the three villages.

In Wainwright, both sites are located in dry upland tundra. Site A is closer to the coastline than Site B is but does not have any small ponds nearby. Site B is located next to a road and a large sewage pond that was attractive to birds and was used by Spectacled Eiders. Movement rates at Site B were focused primarily along the coastline and around the sewage pond. Based on an evaluation of the habitat at both locations and the recorded bird movements at Site B (but not Site A), we may expect Site A to have fewer avian issues with the proposed development.

The complete ABR, Inc. site characterization and avian field study report of the proposed Wainwright wind farm is forwarded with this conceptual design report.

Geotechnical Report

WHPacific commissioned Golder Associates of Anchorage, Alaska to perform a non-field study assessment of likely geotechnical conditions in Point Hope, Point Lay, and Wainwright in order to identify potential hazards and provide conceptual foundation recommendations for the proposed wind tower sites in the three communities. Golder's work is documented in a report titled: *Geotechnical Review and Feasibility Studies for Wind Turbines: Point Hope, Point Lay, and Wainwright, Alaska*, dated January 27, 2012.

The Golder report states the following regarding Wainwright: The village of Wainwright is located on Alaska's northwest coast, about 3 miles northeast of the Kuk River Estuary. Wainwright lies within Alaska's Arctic Coastal Plain physiographic province characterized by gentle topography, ice-bonded permafrost soils, wet tundra, oriented thaw lakes and meandering stream channels. Wainwright is in a zone of cold continuous permafrost. The terrain has little relief, although the polygonal patterned ground from ice-wedge development is evident on the terrain.

The subsurface soil conditions in Wainwright appear to be similar throughout the village. Subsurface soils typically consist of a thin live organic tundra mat, underlain by ice-rich organic soils and ice rich silts and sandy silts. Silty sand, sand and gravelly sand generally underlay the area, and have been observed at depths ranging from about 15 feet to 20 feet deep, although coarse grained deposits may be deeper in some locations.

The area is underlain by continuous permafrost, although shallow zones of unfrozen soil have been observed associated with drained lake beds. The ice content of the soils varies widely. Polygonal ground is present throughout the area. Massive ice is common in Wainwright and is typically observed at an average of 3 feet below the natural ground surface.

A proposed wind turbine sites in Wainwright are located northeasterly of the village on relatively undisturbed tundra. Reviewed areal imagery shows that both sites are characterized by polygonal patterned ground. Thaw lake and drained lake beds do not appear to be present at the sites, although some localized ponding may be present or nearby.

Subsurface conditions are expected to be similar to that observed elsewhere in the Wainwright area, consisting of a thin surficial organic mat, underlain by 1 to 5 feet of organic silt, and further underlain by deposits of silt, sandy silt and silty sand. Coarse grained deposits of sand and gravel may underlie the fine-grained deposits, and could be encountered as shallow as 15 feet deep. The soils are expected to be icy, with massive wedge-ice common and moisture contents in excess of thawed state saturation in the fine-grained deposits. Pore water salinities are not expected to affect the thermal state of the soils. Ground temperatures at the site are expected to be typical of the Wainwright area, ranging between about 14 °F and 22 °F.

The tower site subsurface conditions will most likely consist of very icy silt to massive ice under the tundra. The tundra mat must be protected during the tower construction and for operations and maintenance access. A gravel pad should be included with the project for construction and regular maintenance. The gravel pad should be 4 to 5 feet thick but a thinner section may be feasible if rigid insulation is placed within the pad fill.

An adfreeze pile foundation system should be used for the tower foundation with an above grade pile cap/tower base system. Cast-in-place concrete, pre-cast concrete and steel frame pile cap/tower base systems have been used in permafrost regions.

The complete Golder Associates geotechnical review report of the proposed Wainwright wind farm is forwarded with this conceptual design report.

Noise Analysis

As part of a 2007 Powercorp Alaska, LLC Preliminary Wind Feasibility Report of Kaktovik, Point Hope and Point Lay, Michael Minor & Associates of Portland, Oregon was commissioned to complete a desktop analysis of the expected noise impact of wind turbines at Site A (this was the only site considered at that time). This work was documented in a report titled: *Noise Analysis Memorandum of the Point Hope*

Wind Farm, dated October 14, 2007. Because Point Hope Site A is approximately the same distance from the village of Point Hope as Wainwright Site B is from the village of Wainwright, its synopsis is included here for information purposes.

The noise analysis memorandum summary stated: This project will install a wind turbine generator farm outside of Point Hope, Alaska. The project proposes to use one Vestas V47, four Vestas V27's, or one Führländer 600 wind turbine generator(s). The wind turbine nearest to the eastern edge of town will be located approximately 3,400 feet to the west. Noise due to the operation of the wind turbines is expected to be audible in the town, although the overall noise levels are low and are not projected to exceed 31 to 34 dBA. In addition, the noise from the wind turbines should not exceed the ambient by more than 1 to 5 dBA except in extreme cases accompanied by high winds, low ambient noise levels and frozen ground.

The complete Michael Minor & Associates noise analysis memorandum of North Slope Borough wind farms is forwarded with this conceptual design report.

Permitting and Environmental Review

The environmental permitting requirements listed below are discussed in *Alaska Wind Energy Development: Best Practices Guide to Environmental Permitting and Consultations*, a study prepared by URS Corporation for the Alaska Energy Authority in 2009.

Alaska Pollution Discharge Elimination System

State regulations (18 AAC 83) require that all discharges to surface waters, including storm water runoff, be permitted under the Alaska Pollution Discharge Elimination System (APDES). The goal of the program is to reduce or eliminate pollution and sediments in stormwater and other discharges to surface water. Under the state APDES program, projects that disturb one or more acre of ground are subject to the terms of the Alaska Construction General Permit (CGP) and are required to develop a project Storm Water Pollution Prevention Plan (SWPPP) outlining measures to control or eliminate pollution and sediment discharges. The proposed projects in Point Hope, Point Lay and Wainwright are likely to disturb more than one acre of ground during the construction of proposed wind turbines, supporting infrastructure and access roads and would be subject to the requirements of the CGP. Prior to construction, the contractor would be required to file a Notice of Intent (NOI) with the Alaska Department of Environmental Conservation (ADEC) prior to submitting the project SWPPP. ADEC would issue an APDES permit following the public comment period.

US. Fish and Wildlife Service/National Marine Fisheries Service

Both the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) list Threatened and Endangered (T&E) that may occur in the vicinity of Point Hope, Point Lay, and Wainwright, Alaska. T&E species listed by the USFWS in the vicinity of the project area may include the short tailed albatross, polar bear, Steller's eider, spectacled eider. Candidate species that may be found in the area include the yellow billed loon, Kittlitz's murrelet, and the Pacific walrus. While NMFS lists marine T&E species, the bearded seal and ring seal may haul on beaches in the vicinity of the project area. A discussion with the USFWS will be initiated, and at a minimum, a letter and a map will be sent requesting their opinion regarding the level of consultation needed to proceed with the construction of the project.

USFWS regulations and guidance under the Migratory Bird Treaty Act prohibits the taking of active bird nests, eggs and young. In their Advisory: Recommended Time Periods for Avoiding Vegetation Clearing in Alaska in order to protect Migratory Birds, USFWS has developed “bird windows” statewide that prohibit clearing activity. The bird window for the Northern region of Alaska, including the communities of Point Hope, Point Lay and Wainwright is June 1^{st} – July 31^{st} for shrub and open type habitats (tundra and wetlands) and May 20^{th} – September 15^{th} for nesting seabird colonies. The clearing window for black scoter habitat is through August 10^{th}. Clearing prior to these dates is allowed. If clearing has already occurred then construction may proceed during these dates.

USFWS Wind Turbine Guidelines Advisory Committee developed guidelines and recommendations for wind power projects to avoid impacts to birds and bats. These recommendations have been released to the public as draft U.S. Fish and Wildlife Service Land-Based Wind Energy Guidelines and will be referred to during design and construction of a wind turbine project in Point Hope, Point Lay and Wainwright.

In February 2014, ABR Inc. completed a report prepared for the North Slope Borough titled “Site Characterization and Avian Field Study for the Proposed Community-Scale Wind Project in Northern Alaska”. The study was for the communities of Point Hope, Point Lay and Wainwright. The ABR study characterized habitat, bird abundance, migration and nesting movements of observed species and analysis of the impacts on species of concern, specifically spectacled eiders (endangered), Steller’s eiders (endangered) and yellow-throated loons (threatened).

The site characterization was focused on a one-mile radius study area surrounding each of the proposed turbine locations in each of the communities. The study concluded that both the most abundant bird species and those with limited populations like the Steller’s and spectacled eiders are most at risk from wind infrastructure. The ABR report states impacts to Steller’s eiders should be considered in all three project areas. Spectacled eiders were not recorded near any of the proposed turbine locations and concluded the risk to this species are low. Yellow billed loons, a USFWS species of concern, were active in Point Hope, were active to a lesser extent in Point Lay, and not recorded in Wainwright. Red throated loons, which is a BLM Alaska Natural Heritage Program “watch” species, were absent from Point Hope but were observed in Point Lay and Wainwright. Red throated loons were the most observed among the focal species discussed in the report and were often observed flying low, below the rotor swept area (RSA).

The report concludes that post-construction monitoring data suggests wind infrastructure operates in rural Alaska with limited direct impacts to bird species; however, some impacts would be expected due to migration and breeding movements. Turbine selection and temporal adjustments to operation could mitigate potential impacts.

Federal Aviation Administration

Prior to turbine construction an FAA Notice of Proposed Construction or Alteration (Form 7460-1) must be completed. Filing a 7460-1 may result in additional discussions with the FAA regarding turbine siting and appropriate lighting requirements that would need to be incorporated into the project specifications.

U.S. Army Corps of Engineers

The US Army Corps of Engineers (USACE) requires a permit for the placement of fill in "waters of the United States", including wetlands and streams, under Section 404 of the Clean Water Act (CWA). The proposed wind turbine site(s) and supporting infrastructure in Point Hope, Point Lay and Wainwright may be all, or partially located on wetlands. The project must receive a Section 404 permit from the Alaska District USACE and an accompanying U.S. Environmental Protection Agency (EPA) Section 401 Water Quality Certification if the project is situated on, or will impact waters of the US. Currently, Individual Permits and Nationwide 12 permits are being issued for wind power projects in Alaska. An individual permit would be required for activities related to the construction of access roads or pads in wetlands. A Nationwide 12 Permit would be appropriate for activities related to utility installation (i.e. power lines). Depending on the site selection and potential impacts, a jurisdictional determination (wetland delineation) may be necessary to obtain a Section 404 permit.

Alaska Department of Fish and Game

The Alaska Department of Fish and Game (ADF&G) oversees activities that may have an impact on fish habitat and anadromous fish streams. An ADF&G Title 16 Fish Habitat Permit would be required if the proposed project includes construction of access roads and infrastructure that may impact fish habitat or would involve installing a culvert in a fish stream.

State Historic Preservation Office

Consultation with the State Historic Preservation Office (SHPO) for State of Alaska-funded projects is required under the State Historic Preservation Act. The act requires that all state projects be reviewed for potential impacts to cultural and historic resources. During the permitting phase of the project prior to construction, consultation with the SHPO would be initiated to determine if the project may impact these resources. The extent of needed infrastructure (pads and new roads) and the presence of known archaeological sites in the vicinity of the project area may trigger the SHPO to recommend an archaeological survey of the site.

Wind-Diesel Hybrid System Overview

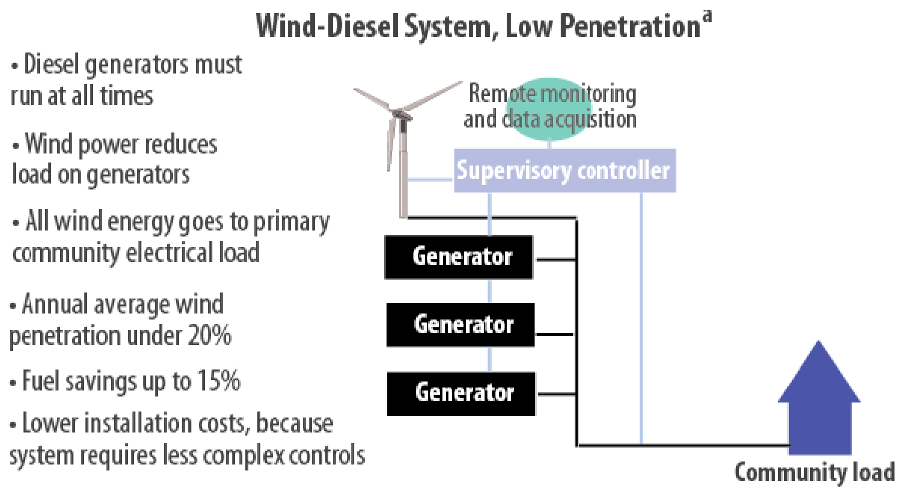
There are now over twenty-four wind-diesel projects in the state, making Alaska a world leader in wind-diesel hybrid technology. There are a variety of system configurations and turbine types in operation and accordingly there is a spectrum of success in all of these systems. As experience and statewide industry support has increased so has overall system performance.

Wind-diesel Design Options

Wind-diesel power systems are categorized based on their average penetration levels, or the overall proportion of wind-generated electricity compared to the total amount of electrical energy generated. Commonly used categories of wind-diesel penetration levels are low, medium, and high; occasionally very low is also defined as a category. Wind penetration level is roughly equivalent to the amount of diesel fuel displaced by wind power. Note however a positive correlation of system control and demand-management strategy complexity with wind power penetration.

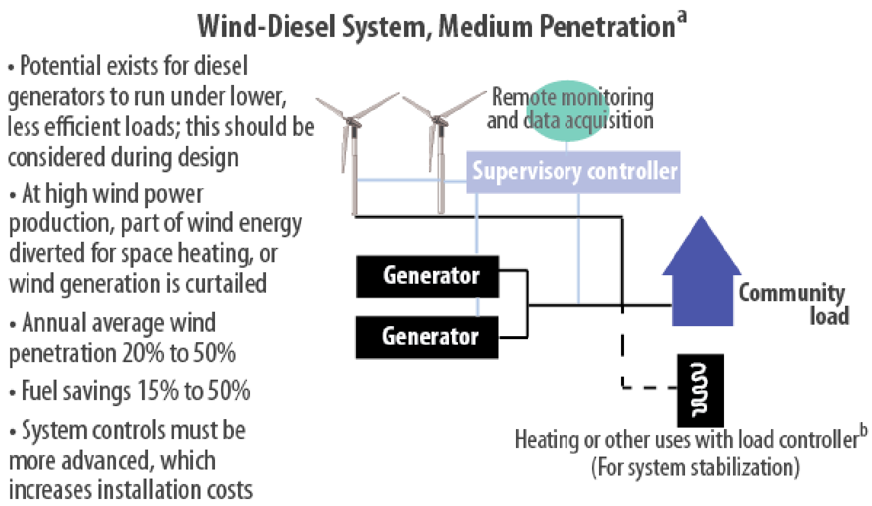
Low Penetration Configuration

Low (and extremely low) penetration wind-diesel systems require the fewest modifications to the existing system. However, they tend to be less economical than higher penetration configurations due to the limited annual fuel savings compared to fixed project costs, such as new distribution connection.



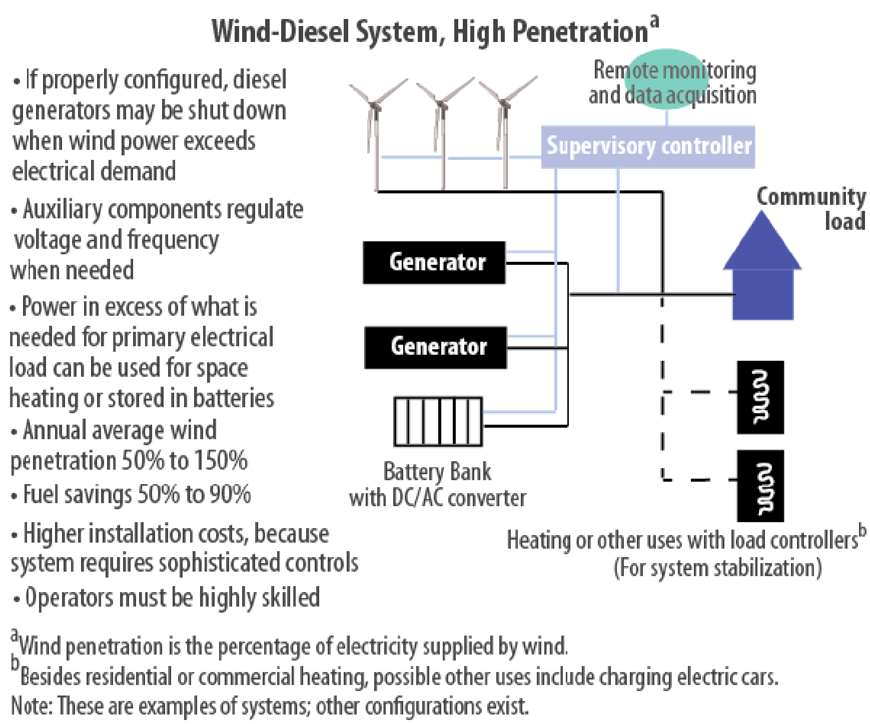
Medium Penetration Configuration

Medium penetration wind-diesel requires relatively sophisticated power quality control due to occasional circumstance of wind generation exceeding load demand and generally are with a full-time diesels-on requirement. Medium penetration is often chosen as a compromise between the minimal benefit of low penetration and the considerable complexity of high penetration, but experience has indicated that this may be misleading. Power quality can be difficult to maintain with typical medium penetration configuration design and upgrades necessary to improve power quality control edge enough toward high penetration that the greater economic benefits of high penetration wind are not captured due to insufficient wind turbine capacity.



High Penetration Configuration

High penetration configuration design typically enables diesels-off operation and uses a significant portion of the wind energy for thermal heating loads. The potential benefit of high penetration can be significant, but system complexity requires a significant investment in project commissioning, operator training, and strong management practices.



Wind-diesel penetration level are summarized table below in a table developed by Alaska Energy Authority. Note that instantaneous penetration level is much more important for system configuration design than average penetration. One way to appreciate instantaneous penetration and design is to consider the brakes of an automobile: they are designed for the maximum (or instantaneous) vehicle speed of, say, 120 mph, not the vehicle's typical day-to-day average speed of 45 mph. If the brakes were designed for average vehicle speed, one would be unable to stop when driving at highway cruising speeds, let alone maximum vehicle speed!

The annual contribution of wind energy, expressed as percentage of wind energy compared to load demand, is the average penetration level. This defines the economic benefit of a project.

Categories of wind-diesel penetration levels

Penetration Category	Wind Penetration Level		Operating Characteristics and System Requirements
	Instantaneous	Average	
Very Low	<60%	<8%	• Diesel generator(s) runs full time • Wind power reduces net load on diesel • All wind energy serves primary load • No supervisory control system
Low	60 to 120%	8 to 20%	• Diesel generator(s) runs full time • At high wind power levels, secondary loads are dispatched to insure sufficient diesel loading, or wind generation is curtailed • Relatively simple control system
Medium	120 to 300%	20 to 50%	• Diesel generator(s) runs full time • At medium to high wind power levels, secondary loads are dispatched to insure sufficient diesel loading • At high wind power levels, complex secondary load control system is needed to ensure heat loads do not become saturated • Sophisticated control system
High (Diesels-off Capable)	300+%	50 to 150%	• At high wind power levels, diesel generator(s) may be shut down for diesels-off capability • Auxiliary components required to regulate voltage and frequency • Sophisticated control system

Recommended Penetration Configuration

In general, medium penetration is a good design compromise as it enables a relatively large amount of displaced fuel usage but requires only a moderate degree of system complexity. Medium penetration is the preferred system configuration of Alaska Village Electric Cooperative (AVEC), owner and operator of eleven wind-diesel systems statewide, and Alaska's leading utility developer of wind-diesel. AVEC's experience provides a useful guide for North Slope Borough as it develops wind energy for its communities.

It should be noted however that not in the wind-diesel industry categorize wind penetration as does Alaska Energy Authority. Many collapse the penetration categories to just two: low and high. This simplification is in recognition that system design is dependent on the percentage of instantaneous, not average penetration. The nuances beyond that are diesels-off capability and inclusion of storage options. For village wind power, a project capable of off-setting a worthwhile amount of diesel fuel and providing real economic benefit to the community invariably must be high penetration by the alternate definition. With this in mind, limiting average penetration to a compromise level of 20 to 50 percent may, in some respects, make very little sense. With a design configuration capable of controlling 100 percent and higher instantaneous penetration, there is no particular reason to limit average penetration to a pre-determined percentage as with Alaska Energy Authority's definition of medium penetration.

Wind-Diesel System Components

Listed below are the main components of a medium to high-penetration wind-diesel system:

- Wind turbine(s), plus tower and foundation
- Supervisory control system
- Secondary load (plus controller)
- Deferrable load
- Interruptible load
- Storage
- Synchronous condenser

Wind Turbine(s)

Village-scale wind turbines are generally considered to be 50 kW to 500 kW rated output capacity. This turbine size once dominated with worldwide wind power industry but has long been left behind in favor of much larger 1,500 kW plus capacity turbines. Conversely, many turbines are manufactured for home or farm application, but generally these are 10 kW capacity or less. Consequently, few new village size-class turbines are on the market, although a large supply of used and/or remanufactured turbines are available. The latter typically result from repowering older wind farms in the United States and Europe with new, larger wind turbines.

Supervisory Control System

Medium- and high-penetration wind-diesel systems require fast-acting real and reactive power management to compensate for rapid variation in village load and wind turbine power output. A wind-diesel system master controller, also called a supervisory controller, would be installed inside the Wainwright power plant or in a new module adjacent to it. The supervisory controller would select the optimum system configuration based on village load demand and available wind power.

Synchronous Condenser

A synchronous condenser, also referred to as a synchronous compensator, is a specialized synchronous-type electric motor with an output shaft that spins freely. Its excitation field is controlled by a voltage regulator to either generate or absorb reactive power as needed to support grid voltage or to maintain the grid power factor at a specified level. A synchronous condenser or similar device is needed to operate in diesels-off mode with wind turbines equipped with asynchronous (induction) type generators. This is to provide the reactive power necessary for operation of the asynchronous generator.

Secondary Load

A secondary or “dump” load during periods of high wind is required for a wind-diesel hybrid power system to operate reliably and economically. The secondary load converts excess wind power into thermal power for use in space and water heating through the extremely rapid (sub-cycle) switching of heating elements, such as an electric boiler imbedded in the diesel generator jacket water heat recovery loop. A secondary load controller serves to stabilize system frequency by providing a fast responding load when gusting wind creates system instability.

An electric boiler is a common secondary load device used in wind-diesel power systems. An electric boiler (or boilers), coupled with a boiler grid interface control system, could be installed in Wainwright to absorb excess instantaneous energy (generated wind energy plus minimum diesel output exceeds electric load demand). The grid interface monitors and maintains the temperature of the electric hot water tank and establishes a power setpoint. The wind-diesel system master controller assigns the setpoint based on the amount of unused wind power available in the system. Frequency stabilization is another advantage that can be controlled with an electric boiler load. The boiler grid interface will automatically adjust the amount of power it is drawing to maintain system frequency within acceptable limits.

Deferrable Load

A deferrable load is electric load that must be met within some time period, but exact timing is not important. Loads are normally classified as deferrable because they have some storage associated with them. Water pumping is a common example - there is some flexibility as to when the pump actually operates, provided the water tank does not run dry. Other examples include ice making and battery charging. A deferrable load operates second in priority to the primary load and has priority over charging batteries, should the system employ batteries as a storage option.

Interruptible Load

Electric heating either in the form of electric space heaters or electric water boilers could be explored as a means of displacing stove oil with wind-generated electricity. It must be emphasized that electric heating is only economically viable with excess electricity generated by a renewable energy source such as wind and not from diesel-generated power. It is typically assumed that 40 kWh of electric heat is equivalent to one gallon of heating fuel oil.

Storage Options

Electrical energy storage provides a means of storing wind generated power during periods of high winds and then releasing the power as winds subside. Energy storage has a similar function to a secondary load but the stored, excess wind energy can be converted back to electric power at a later time. There is an efficiency loss with the conversion of power to storage and out of storage. The descriptions below are informative but are not currently part of the overall system design.

Flywheels

A flywheel energy system has the capability of short-term energy storage to further smooth out short-term variability of wind power, and has the additional advantage of frequency regulation. The smallest capacity flywheel available from Powercorp (now ABB), however, is 500 kW capacity, so it is only suitable for large village power generation systems.

Batteries

Battery storage is a generally well-proven technology and has been used in Alaskan power systems including Fairbanks (Golden Valley Electric Association), Wales and Kokhanok, but with mixed results in the smaller communities. Batteries are most appropriate for providing medium-term energy storage to allow a transition, or bridge, between the variable output of wind turbines and diesel generation. This “bridging” period is typically 5 to 15 minutes long. Storage for several hours or days is also possible with batteries, but this requires higher capacity and cost. In general, the disadvantages of batteries for utility-scale energy storage, even for small utility systems, are high capital and maintenance costs and limited lifetime. Of particular concern to rural Alaska communities is that batteries are heavy and expensive ship and most contain hazardous substances that require special removal from the village at end of service life and disposal in specially-equipped recycling centers.

There are a wide variety of battery types with different operating characteristics. Advanced lead acid and zinc-bromide flow batteries were identified as “technologically simple” energy storage options appropriate for rural Alaska in a July, 2009 Alaska Center for Energy and Power report on energy storage. Nickel-cadmium (NiCad) batteries have been used in rural Alaska applications such as the Wales wind-diesel system. Advantages of NiCad batteries compared to lead-acid batteries include a deeper discharge capability, lighter weight, higher energy density, a constant output voltage, and much better performance during cold temperatures. However, NiCad’s are considerably more expensive than lead-acid batteries, experience a shorter operational life (approx. 5 years vs. 20 years for lead-acid) and one must note that the Wales wind-diesel system had a poor operational history with NiCad batteries and has not been functional for a number of years.

Because batteries operate on direct current (DC), a converter is required to charge or discharge when connected to an alternating current (AC) system. A typical battery storage system would include a bank of batteries and a power conversion device. The batteries would be wired for a nominal voltage of roughly 300 volts. Individual battery voltages on a large scale system are typically 1.2 volts DC. Recent advances in power electronics have made solid state inverter/converter systems cost effective and preferable a power conversion device. The Kokhanok wind-diesel system is designed with a 300 volts DC battery bank coupled to a grid-forming power converter for production of utility-grade real and reactive power. Following some design and commissioning delays, the solid state converter system in Kokhanok should be operational by early 2015 and will be monitored closely for reliability and effectiveness.

Wind-Diesel Philosophy

Installing wind turbines and creating a wind-diesel power system in an Alaskan village is a demanding challenge. At first glance, the benefits of wind power are manifest: the fuel is free and it is simply a manner of capturing it. The reality of course is more complicated. Wind turbines are complex machines and integrating them into the diesel power system of a small community is complicated. With wind-diesel, a trade-off exists between fuel savings and complexity. A system that is simple and inexpensive to install and operate will displace relatively little diesel fuel, while a wind-diesel system of considerable complexity and sophistication can achieve very significant fuel savings.

The ideal balance of fuel savings and complexity is not the same for every community and requires careful consideration. Not only do the wind resource, electric and thermal load profiles, and powerhouse suitability vary between villages, so does technical capacity and community willingness to accept the opportunities and challenges of wind power. A very good wind-diesel solution for one village may not work as well in another village, for reasons that go beyond design and configuration questions. Ultimately, the electric utility and village residents must consider their capacity, desire for change and growth, and long-term goals when deciding the best solution that meets their needs.

The purpose of this conceptual design report is to introduce and discuss the viability of wind power in Wainwright. As discussed, many options are possible, ranging from a very simple low penetration system to a highly complex, diesels-off configuration potentially capable of displacing 50 percent or more of fuel usage in the community. It is possible that North Slope Borough and Wainwright residents ultimately will prefer a simple, low penetration wind power system, or alternatively a very complex high penetration system, but from past discussions and work it appears that a moderate approach to wind power in Wainwright is preferable, at least initially.

With a moderately complex project design framework in mind, a configuration of relatively high wind turbine capacity with no electrical storage and no diesels-off capability was chosen. This provides sufficient wind capacity to make a substantive impact on fuel usage but does not require an abrupt transition from low to high complexity. Although conceptually elegant, there is a trade-off to consider with this approach. Installing a large amount of wind power (600 to 800 kW of wind capacity is recommended) is expensive, but without electrical or thermal storage some of the benefits of this wind power capacity may not be used to best advantage.

The thermodynamics of energy creation and use dictates that wind power is more valuable when used to offset fuel used by diesel generators to generate electricity than fuel used in fuel oil boilers to serve thermal loads. More specifically, boilers convert fuel oil to hydronic heat at 85 to 95 percent thermal efficiency, but diesel generators convert fuel oil (diesel) to electrical energy at only 35 to 45 percent thermal efficiency, hence it is preferable to replace the least efficient generation method first. Referring to the energy production summaries for the turbine configurations under *Modeling Results*, one can see that the wind turbines are expected to produce relatively small amounts of excess electricity, even at 85 percent turbine availability. This excess electricity, although minimal, must be shunted via a secondary load controller to the diesel generator heat recovery loop or simple radiation heaters to avoid curtailing wind turbines during periods of high wind and relatively light electrical load.

Although perhaps not readily apparent in the report, this compromise of wind capacity versus complexity is contained within the economic benefit-to-cost tables. This compromise, which is endemic to wind-diesel, results in high capital costs, but usage of the energy generated is imperfect from an efficiency point of view. The most efficient usage of wind energy from a technical point of view – offset of electrical power, may be too expensive from a cost-benefit perspective.

It is important not to focus strictly on benefit-to-cost ratio of a particular configuration design or particular turbine option, but also consider a wider view of the proposed wind project for Wainwright. Installing approximately 700 kW capacity of wind power has considerable short-term benefit with reduction of diesel fuel usage, but more importantly it would provide a platform of sustainable renewable energy growth in Wainwright for many years to come. This could include enhancements such as additional thermal load offset, battery storage and/or use of a flywheel to enable diesels-off capability, creation of deferred heat loads such as water heating, and installation of distributed electrical home heat units (Steffis heaters or similar) controlled by smart metering. The latter, presently operational to a limited extent in the villages of Kongiganak, Kwigillingok, Tuntutuliak, has enormous potential in rural Alaska to not only reduce the very high fuel oil expenses borne by village residents, but also to improve the efficiency and cost benefit of installed and future wind power projects. These opportunities and benefits are tangible and achievable, but their cost benefit was not modeled in this report.

Lastly, it must be acknowledged that a wind power project in Wainwright will provide benefits that are not easily captured by economic modeling. These are the *externalities* of economics that are widely recognized as valuable, but often discounted because they are considered by some as soft values compared to the hard numbers of capital cost, fuel quantity displaced, etc. These include ideals such as long-term sustainability of the village, independence from foreign-sourced fuel, reduction of Wainwright's carbon footprint, and opportunities for education and training of local residents. Beyond these somewhat practical considerations, there is the simple moral argument that renewable energy is the right thing to do, especially in a community such as Wainwright that is in the vanguard of risk from climate change due to global warming.

Wainwright Powerplant

Electric power (comprised of the diesel power plant and the electric power distribution system) in Wainwright is provided by North Slope Borough Public Works Department, the utility for all communities on the North Slope, with the exception of Deadhorse and Barrow. The existing power plant in Wainwright consists of three Caterpillar 3508 diesel generators rated at 430 kW output, and two Caterpillar 3512 diesel generator rated at 950 kW output.

Wainwright powerplant diesel generators and bays

Generator	Electrical Capacity	Diesel Engine Model
1	440 kW	Caterpillar 3508
2	440 kW	Caterpillar 3508
3	440 kW	Caterpillar 3508
4	910 kW	Caterpillar 3512
5	910 kW	Caterpillar 3512

Switchgear

Generator sets in the Wainwright power plant are controlled by Woodward 2301A load sharing and speed control governors with protection and alarms initiated by discreet protective relays for each unit. A user-programmable PLC controller with SCADA interface automatically parallels and dispatches the diesel generators, based on system load and operator-programmable preferences, via a unit-based auto synchronizer.

Geospatial Perspective of Electrical Load

The power plant is located at the north central end of the village and has feeders that run parallel and south from the power plant, on the east and west sides of the village. The west feeder serves a tract owned by Olgoonik Corporation which has a large load. The school and a hotel are located toward the southeast side of the village and fed from the east feeder. Readings taken in the power plant for several days in late October, 2013 indicated that the east feeder carried approximately 60% of total load and west feeder about 40% of the load.

Refer to Appendix C for the Wainwright power distribution grid schematic.

Phase Balance of Electrical Load

Ross Klooster of WHPacific made several per-phase load observations at Wainwright over a two day period in autumn 2013. His observations indicated excellent per-phase load balance. At the time of observation the average current, calculated from several measurements on all three phases, was 983 amps (817 kW). Phase A current averaged 997 amps (1.4% above average), phase B averaged 985 amps (average) and phase C averaged 967 amps (1.6% below average).

Transformers

The main transformers, serving each feeder at the power plant, are conservative. In an emergency, each is capable of supporting the entire village load during peak winter loads. The distribution transformers are also believed to be liberally-sized for demand with capacity to be loaded to 150% of rated load during colder winter temperatures. This is based on experience with facility loads in general; there is no recorded data to confirm this.

Phase and/or Transformer Capacity Location(s) for Additional Load

The generation and distribution systems have significant reserve capacity and redundancy. Power lines are gradually being upgraded from #2 ACSR to 1/0 AAAC to increase conductor strength for snow and ice loading and to immune the system from electrolysis corrosion. As an additional benefit, however, this will also increase the load capacity of the system, reduce line loss, and lessen voltage drop through the system. The Wainwright distribution system has adequate reserve capacity for additional load anywhere in the systems.

Condition of Distribution Lines, Transformers, Poles

North Slope Borough villages generally have some of the best maintained power systems in rural Alaska. The original power poles in Wainwright have largely been replaced over the years. Most of the secondary conductor has been replaced in the past five years and distribution transformers are being replaced with larger transformers to meet increasing residential demand. As discussed in the preceding section, primary conductor is gradually being replaced and upgraded with larger all-aluminum alloy conductor to improve strength in wind and ice loading and prevent degradation due to electrolysis, a problem which has plagued ACSR conductor in coastal villages.

Parasitic and Other Losses

As documented in the 2013 PCE Report, distribution line loss in Wainwright for fiscal year 2013 was 9.3% and powerhouse consumption was 5.7%, yielding a rather low 85% ratio of sold vs. generated energy. This indicates a potential problem with the electrical distribution system itself and/or possibly with billing and recordkeeping. This issue will be investigated during the design phase of the project and addressed as an integral component of the wind-diesel system design and operations plan.

Wind Turbine Options

Turbine choice was oriented toward turbines that are large enough to match well with Wainwright's electrical load. Turbines that meet these criteria are generally in the 100 to 750 kW size range. The wind power industry, however, does not provide many options as village wind power is a small market worldwide compared to utility grid-connected projects where wind turbines are 1,000 kW and larger capacity, or home and farm applications where wind turbines are generally 10 kW or less capacity. For this project, four wind turbines are considered:

1. Aeronautica AW/Siva 250: 250 kW rated output; new
2. EWT DW 54-900: 900 kW rated output; new
3. Northern Power Systems 360-39-30: 360 kW rated output; new
4. Vestas V27: 225 kW rated output; remanufactured

The choice of selecting new or remanufactured wind turbines is an important consideration and one which North Slope Borough is carefully considering at present through a separately-contracted evaluation effort which included visits to the offices and factories of Aeronautica, Northern Power, and Halus. There are advantages and potential disadvantages of each turbine, including cost, support and parts availability. Note however that the three wind turbines presented in this report have solid track records and good support capacity within Alaska. The turbine evaluation report will be forwarded separately from this conceptual design report.

Aeronautica AW/Siva 250

Aeronautica Windpower, with offices in Plymouth, Massachusetts and production facilities in Portsmouth, New Hampshire, manufactures the AW/Siva 250 wind turbine in two rotor configurations: 29 meters for IEC wind class design IIA sites and 30 meters for IEC wind class IIIA sites. This turbine is a Siva (Germany) licensed design. For Wainwright, the 30 meter version likely would be optimal. This turbine has a 30 meter rotor diameter, is rated at 250 kW power output, is stall regulated, has a gearbox-type drive system, and is equipped with asynchronous (induction type) dual-wound (50 kW and 250 kW) generators. Braking is accomplished by passive and hydraulically-actuated pivotable blade tips and hydraulic disc brakes. The turbine has active yaw control and is available with 30, 40, 45, and 50 meter tubular steel towers.

AW/Siva 250 specifications:

Operational Data		
Start-up wind speed	: 3-4m/sec	
Cut-out wind speed	: 25m/sec	
Nominal wind speed	: 14m/sec	
50 year extreme gust	: 52.5m/sec	
IEC wind class design	: IIA/IIIA	
Rotor		
Type	: Three bladed, horizontal axis	
Position	: Upwind	
Rotary direction	: Clockwise, looking from front	
Number of blades	: 3	
Rotor diameter	: 29m/30m	
Swept area	: 661m^2/707m^2	
Power regulation	: Stall	
Rotor speed	: 40/24 rpm	
Hub type	: Ductile cast iron	
Weight of hub	: 2000kg	
Weight of rotor	: 4150kg	
Blades		
Manufacturer	: LM Glasfiber	
Blade length	: 13.4m	
Type	: Self-supporting	
Material	: Fiberglass reinforced polyester	
Weight per blade	: 750kg	
Generator		
Manufacturer	: ABB/equivalent	
Type	: Dual wound, Asynchronous	
Poles	: 4/6 poles	6/8 poles
Synchronous speed	: 1006/1207 rpm	757/908 rpm
Nominal Power	: 250kW	50kW
Voltage	: 400/480 V AC	
Frequency	: 50/60 Hz	
Insulation class	: F	
Protection Class	: IP54	
Thermal protection	: PT100/thermistor	

Transmission System	
Gearbox Type	: Helical, 3 Stage
Material	: Ductile Cast Iron
Gearbox Cooling	: Oil Cooler
Turbine Controller	
Manufacturer	: Mita-Teknik As Denmark
Type	: Microprocessor based
Remote control	: Gateway SCADA
Hydraulic system	
Manufacturer	: AVN/Hydratech
Motor speed	: 1500 rpm
Nominal effect	: 3kW
Thermal protection	: Thermorelay/thermistor
Yawing System	
Type	: Active
Yaw control	: Wind vane
Yawing gear manufacturer	: Rossi/Bonfiglioli
Drives	: 2 x planetary
Braking systems	
Aerodynamic Brake	
Type	: Pivotable blade tips
Activation	: Passive & hydraulic
Mechanical Brake	
Type	: Disc Brake
Activation	: Hydraulic
Tower	
Manufacturer	: AW/Siva
Type	: Tubular
Hub Height	: 30/40/45/50m
Weight	: 18/28/34/38 t (approx)
Corrosion protection	: Hot dipped galvanized
Warranty	: 2 Years

EWT DW 54-900

The DW 52/54-900 is a direct-drive, pitch-regulated wind turbine with a synchronous generator and inverter-conditioned power output. More information regarding the EWT DW 52/54-900 wind turbine is attached and available on EWT's website: http://www.ewtdirectwind.com/. The turbine boasts a track record of over 400 operating turbines in many different wind climates. At present, six DW 900 turbines have been installed in Alaska: two each in Delta Junction, Kotzebue and Nome. For Wainwright, the 54 meter rotor version likely would be optimal.

Type	*DW 54 / DW 52*
Rotor diameter	54.0 m / 51.5 m
Variable Rotor Speed	12 to 28 rpm
Nominal Power Output	900 kW
Cut-in wind speed	2.5 m/s
Rated wind speed	13 m/s
Cut-out wind speed (10 minute average)	25 m/s
Survival wind speed	59.5 m/s
Power output control	Pitch controlled variable speed

Type Certificate

IEC 61400 wind class IIIA (DW 54)
IEC 61400 wind class IIA (DW 52)

Drive System
Generator Synchronous air-cooled EWT-design, multi-pole, wound-rotor.
Power converter Full-power, IGBT-controlled AC-DC-AC 'back-to-back' type.

Control System
Bachman PLC control system.
Possibility for remote access via TCP / IP internet and the DMS 2.0 * SCADA system.

Tower
Type Conical tubular steel, internal ascent.
Hub heights 40, 50 and 75 meters.

Safety systems
Main brake action Individual rotor blade pitch (three independent brakes).
Fail-safe brake Individual rotor blade pitch by three independent battery-powered back-up units.

Northern Power Systems 360-39 (NPS 360-39)

At 360 kilowatts of rated power, the new-to-the-market Northern Power 360-39 is an innovative wind turbine with gearless direct drive design, permanent magnet generator, and pleasing aesthetics. The turbine will be marketed in two versions: the NPS 360 for temperature climates and the NPS 360 Arctic for cold climates such as Alaska. Differences between the two include heaters and insulation for the Arctic version, plus certification that metal used in the tower and nacelle frame are appropriate for operation to -40° C (-40° F). Note that design characteristics of the NPS 360-39 will be very similar to the NPS 100 B model turbine which is well represented in Alaska.

According to Northern Power Systems, the proprietary permanent magnet generator is central to the design of the NPS 100 (and the new NPS 360) drivetrain. Permanent magnet generators offer high efficiency energy conversion, particularly at partial load, and require no separate field excitation system. Permanent magnet generators are lighter, more efficient, and require less assembly labor than competing designs. The Northern Power permanent magnet generator was designed in conjunction with its power converter to create an optimized solution tailored for high energy capture and low operating costs.

A key element of Northern Power's direct drive wind turbine design is the power converter used to connect the permanent magnet generator output to the local power system. Northern Power designs and manufactures power converters for its wind turbines in-house, with complete hardware, control design, and software capabilities. In 2006, the American Wind Energy Association (AWEA) awarded its annual Technical Achievement Award to Northern Power's Chief Engineer, Jeff Petter. It recognized his expertise and leadership in the development of Northern Power Systems' FlexPhase™ power converter for mega-watt scale wind turbine applications. The FlexPhase power converter combines a unique, patent-pending circuit design with a high bandwidth control system to provide unique generator management, power quality, and grid support features. The FlexPhase converter platform offers a modular approach with a very small footprint and 20-year design life.

NPS 360-39 Class IIIA general information

Model	NPS 360-39
Design Class	IEC 61400-1, 3rd ed., WTGS IIIA
Power Regulation	Variable speed, pitch control
Orientation	Upwind
Yaw Control	Active
Number of Blades	Three
Rotor Diameter	39 meters
Rated Electrical Power	360 kW
Cut-in/Cut-out Wind Speeds	3 m/sec; 25 m/sec
Controller Type	PLC (programmable logic controller)
Hub Height; tower type	30 meters; 3-section tubular steel monopole

Vestas V27

Halus Power Systems of San Leandro, California remanufactures the legacy suite of Vestas wind turbines, rated from 65 kW (the V15) to 600 kW (the V44). Of most interest to North Slope Borough for Wainwright is the V27 turbine. The V27 is a 27 meter rotor diameter, 225 kW rated output, pitch-controlled, gearbox-type drive system, asynchronous double-wound generator wind turbine originally built by Vestas A/S in Denmark. The turbine has active yaw control and is available with a 32 meter steel tower as standard and higher towers by special fabrication. The Vestas V27 nacelle, tower, and blades can be shipped in standard shipping containers, eliminating the expense and risk of damage with break bulk shipping.

Braking and stopping are accomplished by full feathering of the rotor blades, which is a desirable feature of pitch-controlled wind turbines. An emergency stop activates the hydraulic disk brake, which is fitted to the high speed shaft of the gearbox. All functions of the turbine are monitored and controlled by the microprocessor-based control unit. Blade position (pitch angle) is performed by the hydraulic system, which also delivers hydraulic pressure to the brake system. Both are fail-safe in the sense that loss of hydraulic pressure results in feathering of the rotor blades and activation of the disk brake. Of interest with respect to the pitch system is the mechanical interlink of the three rotor blades contained in the hub nose cone. With this simple but ingenious design, it is not possible for the turbine blades to pitch differently from each other.

The V27 was Vestas' workhorse turbine for many years and thousands were installed worldwide. Design of the turbine pre-dates the IEC 61400-1 standards, but by present criteria the turbine can be considered Class II-A and possibly even Class I-A. The V27 is well regarded as a rugged, tough turbine with an outstanding operational history. Four V27 wind turbines are operational in Alaska: three on Saint Paul Island and one at the Air Force's Tin City Long Range Radar Site. Additionally, two V39 wind turbines were installed by TDX Power in Sandpoint, Alaska and are operational. Because of the large numbers of Vestas turbines (legacy and new) deployed in North America, Vestas continues to maintain multiple facilities in the United States including a large manufacturing facility in Colorado and an office in Portland, Oregon. Vestas can provide technical support and spare parts for their legacy turbines (from V17 through V44) as needed. In addition, due to the large number of deployed turbines in North America and worldwide, spare parts are widely available from many suppliers.

Wind-Diesel HOMER Model

Considering North Slope Borough's goal of displacing as much diesel fuel for electrical generation as possible and yet recognizing the present limitations of high penetration wind power in Alaska and the Borough's desire to operate a highly stable and reliable electrical utility in Wainwright, only the medium penetration wind-diesel configuration scenario was modeled with HOMER software. Note that low penetration wind was not modeled as this would involve use of smaller farm-scale turbines that are not designed for severe cold climates, and low penetration would not meet North Slope Borough's goal of significantly displacing fuel usage in Wainwright.

As previously noted, a medium penetration wind-diesel configuration is a compromise between the simplicity of a low penetration wind power and the significant complexity and sophistication of the high penetration wind. With medium penetration, instantaneous wind input is sufficiently high (at 100 plus percent of the village electrical load) to require a secondary or diversion load to absorb excess wind power, or alternatively, to require curtailment of wind turbine output during periods of high wind/low electric loads. For Wainwright, appropriate wind turbines for medium wind penetration are generally in the 100 to 750 kW range with more numbers of turbines required for lower output machines compared to larger output models.

There are a number of comparative medium penetration village wind-diesel power systems presently in operation in Alaska. These include the AVEC villages of Toksook Bay, Chevak, Savoonga, Kasigluk, Hooper Bay, among others. All are characterized by wind turbines directly connected to the AC distribution system. AC bus frequency control during periods of high wind penetration, when diesel governor control would be insufficient, is managed by the sub-cycle, high resolution, and fast-switching capability of the secondary load controller (SLC). Ideally, the SLC is connected to an electric boiler serving a thermal load as this will enhance overall system efficiency by augmenting the operation of the fuel oil boiler(s) serving the thermal load.

Powerplant

On review of the 2013 powerplant data, it appears that only the Caterpillar 3408 in bay 2 and the Caterpillar 3512 in bays 4 and 5 routinely operate, so for modeling purposes models only these generators will be considered.

Diesel generator HOMER modeling information

Diesel generator	Cat 3508 (bays 1, 2, and 3)	Cat 3512 (bays 4 and 5)
Power output (kW)	440	910
Intercept coeff. (L/hr/kW rated)	0.0237	0.0307
Slope (L/hr/kW output)	0.2377	0.2325
Minimum electric load (%)	15.0% (66 kW)	15.0% (136 kW)
Heat recovery ratio (% of generator waste heat energy available to serve the thermal load; when modeled)	35	35

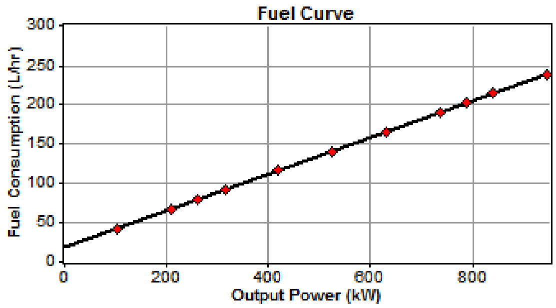
Notes: Intercept coefficient – the no-load fuel consumption of the generator divided by its capacity

Slope – the marginal fuel consumption of the generator

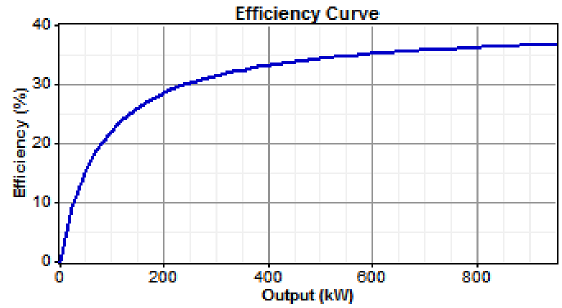
Caterpillar 3508 generator

The graphs below illustrate fuel usage and electrical efficiency curves of the Caterpillar 3508 diesel generator used in Homer modeling.

Cat 3508 fuel curve



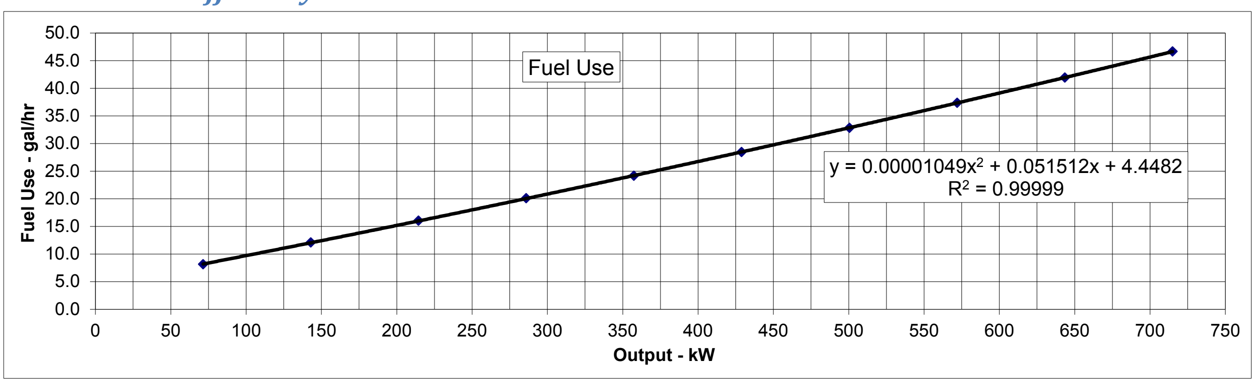
Cat 3508 electrical energy efficiency curve



Caterpillar 3512 generator

The graphs below illustrate fuel usage and electrical efficiency curves of the Caterpillar 3512 diesel generator used in Homer modeling.

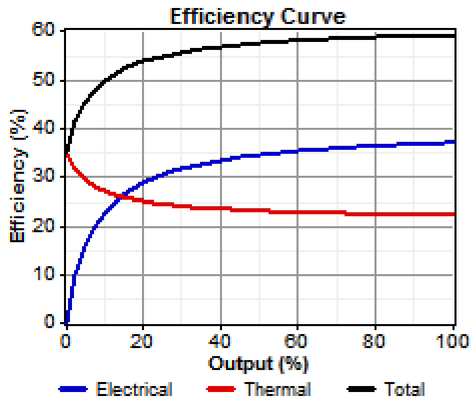
Cat 3512 Fuel Efficiency



Cat 3512 Electrical and Thermal Efficiency

Electrical and thermal efficiency of the Cat 3512 diesel engine is shown below. Note that North Slope Borough did not report a seasonal or other specific scheduling plan, hence Homer software was programmed to select the most efficient diesel for any time period. Also note that Homer was programmed to allow parallel diesel generator operation, which is verfied on review of North Slope Borough's Wainwright power plant logs.

Cat 3512 electrical and thermal efficiency curves



Cat 3512 Recovered Heat Ratio

The 35 percent heat recovery potential of the Cat 3512 generator was derived from technical data supplied by NC Power Systems. Homer software defines the heat recovery ratio as the percentage of generator waste heat energy available to serve the thermal load. Generator waste heat is energy not used for work; work being the energy output of the generator. As the table below indicates (calculated with a 665 kW generator), the recovered heat ratio of the Cat 3512 generator equipped with an after cooler (known also as an intercooler), is 41.8%. Assuming 15% system heat loss, actual heat recovery ratio is 35.5%, which was modeled at 35%.

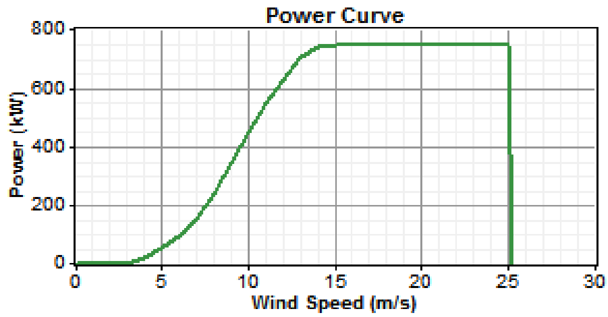
Cat 3512 heat recovery table

		rejected energy			returned energy to JW			electricity	
gen pwr	% load	rej to JW (BTU/m)	rej to atmos (BTU/m)	rej to exhaust (BTU/m)	exh rcov to 350F (BTU/m)	from oil cooler (BTU/m)	from after cooler (BTU/m)	work energy (BTU/m)	TOTAL (BTU/m)
665	100	23,146	5,857	33,610	15,753	4,896	3,037	39,865	102,478
% total energy		22.6%	5.7%	32.8%	15.4%	4.8%	3.0%	38.9%	100.0%
% of remaining non-work energy		37.0%	9.4%	53.7%	25.2%	7.8%	4.9%		
JW and aftercooler		37.0%					4.9%		41.8%
Recovered heat ratio, Homer, 15% heat loss assumed									35.5%

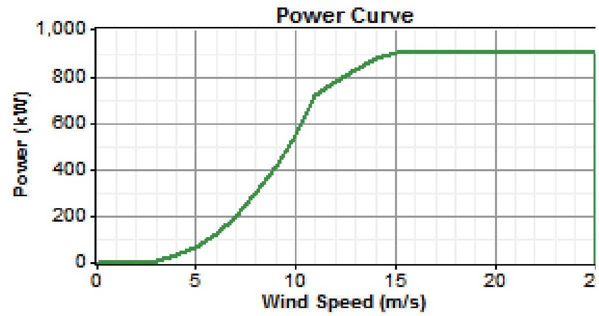
Wind Turbines

Wind turbine options for Wainwright are discussed previously in this report. For Homer modeling, standard temperature and pressure (STP) power curves were used. This is quite conservative in that actual wind turbine power production in Wainwright will typically be higher than predicted by the STP power curves due to the cold temperature climate and consequent high air density of the area.

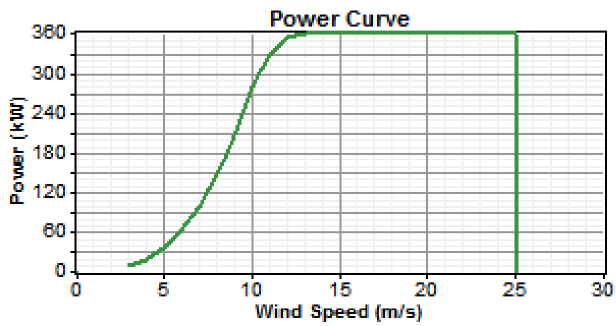
Aeronautica AW/Siva 250 power curve



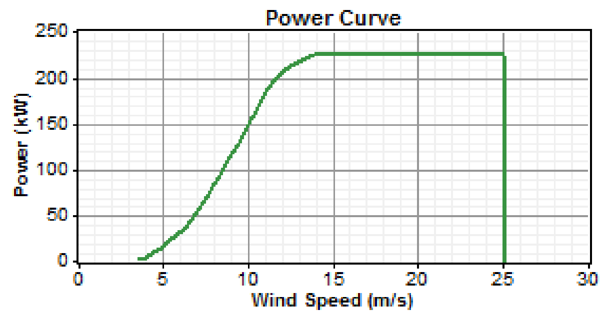
EWT DW 54-900 power curve



Northern NPS 360-39 power curve



Vestas V27 power curve



Electric Load

For modeling purposes with Homer software, the Wainwright electric load was derived from calendar year 2013 Wainwright and Point Hope powerplant data forwarded to V3 Energy, LLC by North Slope Borough in an Excel spreadsheet entitled *2013_Wainwright_PPOR*. The spreadsheet tabulates average power per hour for each diesel engine on-line. If two diesel engines are operating in parallel, individual generator power output is summed to equal total hour (average) load. For each day, generator output is summed to yield kWh produced per generator and aggregate. Below are an example of daily generator output/load data and the monthly Wainwright load profile for 2013.

Completion of the Wainwright powerplant logs was spotty however. With this limitation in mind and with reference to the Statistical Report of the Power Cost Equalization Program, Fiscal Year 2013, the much more complete Point Hope data was scaled 77 percent to match Wainwright's energy usage for the Homer model. This is reasonable as seasonal and diurnal variation will be similar between the two villages with the primary difference magnitude of usage.

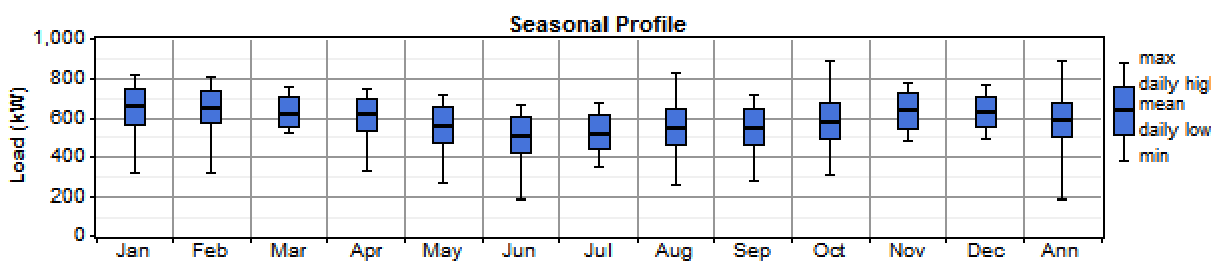
Additionally, it has been noted that the Wainwright (and Point Hope) load data indicates peak load at mid-morning, which is unusually early in the day. It is possible that there is a time error in the PPOR files, such as the nine hour time difference between Coordinated Universal Time (UTC) and Alaska (UTC is a common programming reference for SCADA systems). WHPSG and V3 Energy note, however, that data compiled in the PPOR files are from hand logs; in which case local time would be used. This time and load discrepancy will be evaluated during the design phase of this project, but it is true that North Slope Borough communities exhibit diurnal load profiles with relatively small variation.

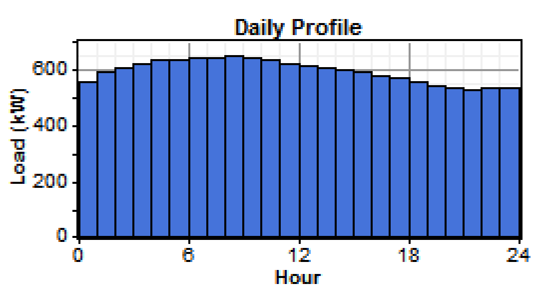
Wainwright powerplant data, sample day, 12/9/2013

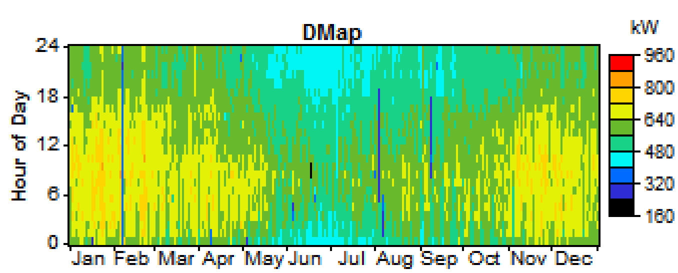
Wainwright Power Plant
December 9, 2013

Hour	Engine 1 Caterpillar 3508 Serial # 70Z00641	Engine 2 Caterpillar 3508 Serial # 70Z00643	Engine 3 Caterpillar 3508 Serial # 70Z00642	Engine 4 Caterpillar 3512 Serial # 67Z1942	Engine 5 Caterpillar 3512 Serial # 67Z1904	Total Hourly Load	Peak Load of the Day
	Total Load	Total Load	Total Load	Total Load	Total Load		
0:00				735		735	910
1:00				720		720	
2:00				734		734	
3:00				698		698	
4:00				692		692	
5:00				700		700	
6:00				745		745	
7:00				772		772	
8:00				730		730	
9:00				794		794	
10:00			278	560		838	
11:00			285	583		868	
12:00			294	616		910	
13:00			270	571		841	
14:00			275	566		841	
15:00			269	567		836	
16:00			273	569		842	
17:00			278	567		845	
18:00			257	536		793	
19:00			262	546		808	
20:00			264	546		810	
21:00			265	550		815	
22:00			253	526		779	
23:00				768		768	
Total	0	0	3,523	15,391	0	**18,914**	

Wainwright electric load







Thermal Load

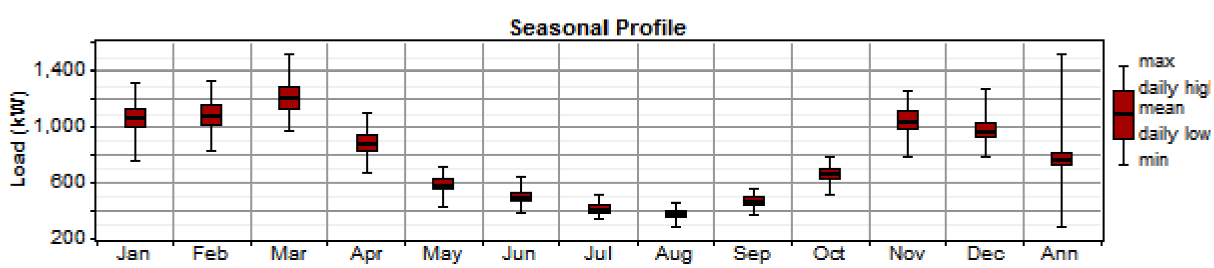
The Wainwright powerplant is equipped with a heat recovery system to extract jacket water waste heat from the diesel generators and supply it to the following village thermal (heat) loads: powerplant, public works/HEMF, and sewer plant. Possible additional connection points are the school, PSO, health clinic, water plant, and fire station, according to a February, 2010 draft RSA Engineering, Inc. report to North Slope Borough entitled *North Slope Borough Village Heat Recovery Project Analysis Report, CIP No. 13-222.* Per the RSA report, the combined design day heat load of the above-referenced structures is 5.03 MMBTU/hr. The additional thermal loads, if connected, would increase the design data heat load by 2.61 MMBTU/hr. Data from the RSA Engineering report details monthly existing waste heat (from the powerplant heat recovery system) consumption and the estimated contribution of waste heat to the actual heat load. Additional data from RSA Engineering is documented in the table below.

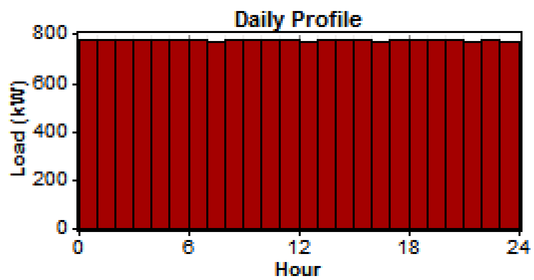
RSA Engineering thermal load data, existing heat loads

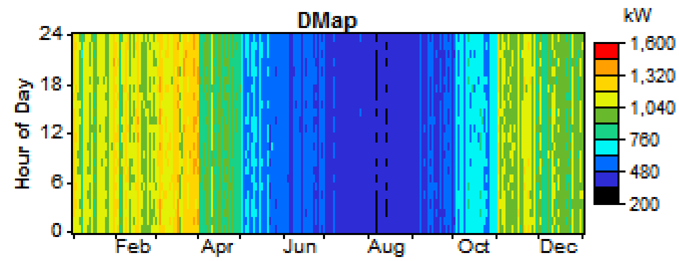
month	avg power (kW)	available waste heat (BTU/hr)	available heat (MMBTU)	available waste heat (kWh)	hourly heat available (kW)	waste heat consumed (BTU/hr)	waste heat consumed (kW)
1	755	2,063,549	1,486	435,432	605	2,063,549	605
2	887	2,423,337	1,745	511,351	710	2,423,337	710
3	639	1,745,766	1,257	368,376	512	1,745,766	512
4	920	2,513,121	1,809	530,297	737	2,513,121	737
5	472	1,290,345	929	272,277	378	1,290,345	378
6	853	2,331,041	1,678	491,876	683	679,843	199
7	693	1,893,136	1,363	399,473	555	585,204	172
8	437	1,193,700	859	251,884	350	812,178	238
9	501	1,369,897	986	289,064	401	1,369,897	401
10	599	1,637,015	1,179	345,428	480	1,637,015	480
11	564	1,542,180	1,110	325,417	452	1,542,180	452
12	718	1,960,276	1,411	413,640	575	1,960,276	575

Data from the above table and additional information obtained from RSA Engineering, Inc. for the village of Kaktovik was converted to kW (heat) load and scaled by a factor of 1.53 as adjustment for the higher thermal loads in Wainwright. Data was uploaded to Homer software to create a thermal load profile for modeling purposes. Diurnal thermal load variation is not contained in the RSA report and is unknown, hence modeled as constant.

Wainwright thermal load







Wind Turbine Configuration Options

Discussions between WHPacific Solutions Group, V3 Energy, LLC and North Slope Borough have indicated that the borough's goals with a wind-diesel system in Wainwright is to offset a significant percentage of fuel used in the powerplant, but not create a highly complex system with significant thermal offset and/or electrical storage capability. This philosophy dictates a medium penetration design approach (see previous section of this report) where wind power supplies approximately one-third of the electric load, but at least one diesel generator is always on-line to provide spinning reserve. Medium penetration design, though, means that instantaneous wind power will at times be well over 100 percent of the load. This can result in unstable grid frequency, which occurs when electrical power generated exceeds load demand. In a wind-diesel power system without electrical storage, there are three options to prevent this possibility:

1. Curtail one or more wind turbines to prevent instantaneous wind penetration from exceeding 100 percent (one must also account for minimum loading of the diesel generator).

2. Install a secondary load controller with a resistive heater. The secondary load controller is a fast-acting switch mechanism commanding heating elements to turn on and off to order to maintain stable frequency. The resistive heating elements can comprise a device as simple as a heater ejecting energy to the atmosphere or an interior air space, or more desirably, an electric boiler serving one or more thermal loads. The boiler can be installed in the powerplant heat recovery loop and operate in parallel with fuel oil boilers.

3. Equip the wind turbines with output controllers (some wind turbines, such as the EWT DW 900 and the NPS 100, are pre-equipped with these controllers) to enable reduction of turbine power to match load demand. This is a more efficient turbine control strategy than curtailment, but of course presents an additional cost to the project and "wastes" wind energy in the sense that one is purposely throttling the turbine(s).

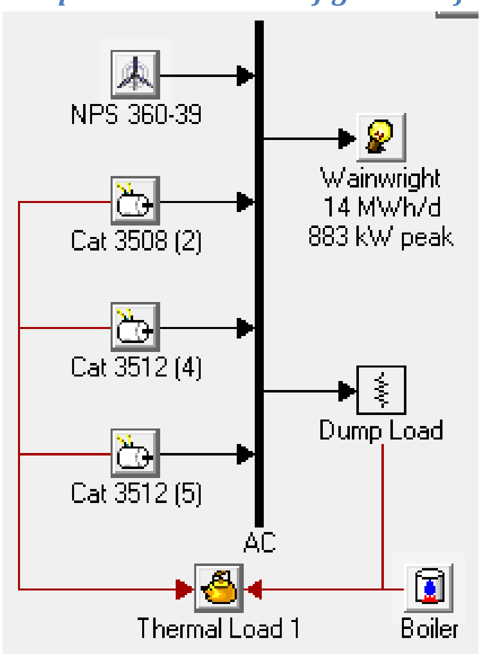
For medium penetration design, frequency control features as described above are necessary because, generally speaking, diesel generators paralleled with wind turbines during periods of high wind energy input may not have sufficient inertia to control frequency by themselves. This design philosophy is true of most wind-diesel systems presently operational in Alaska and provides a solid compromise between the minimal benefit of low penetration systems and the high cost and complexity of high penetration systems.

Many utilities prefer to install more than one wind turbine in a village wind power project to provide redundancy and continued renewable energy generation should one turbine be out-of-service for maintenance or other reasons. This generally sound advice is modified for Wainwright in that a single EWT DW 54-900 turbine configuration is included with multi-turbine configuration options, although 900 kW of turbine capacity in Wainwright is more than medium wind penetration. Referencing the medium wind power penetration design philosophy discussed above, modeled wind turbine configuration options considered in this report are as follows:

- Aeronautica AW 250, three turbines (750 kW capacity)
- EWT DW 54-900, one turbine (900 kW capacity)
- Northern Power NPS 360-39, two turbines (720 kW capacity)
- Vestas V27, four turbines (900 kW capacity)

Turbine types are not mixed, however, as it is assumed that North Slope Borough will select only one type of wind turbine. A typical configuration for this project is show below.

Sample Wind-diesel configuration for Wainwright



System Modeling and Technical Analysis

Installation of wind turbines in medium penetration mode is evaluated in this report to demonstrate the economic impact of these turbines with the following configuration philosophy: turbines are connected to the electrical distribution system to serve the electrical load and a secondary load controller and an electric heater or boiler to divert excess electrical power to offset thermal load(s) via a secondary load controller.

HOMER renewable energy system modeling software was used to analyze the Wainwright power generation system. HOMER was designed to analyze hybrid power systems that contain a mix of conventional and renewable energy sources, such as diesel generators, wind turbines, solar panels, batteries, etc. and is widely used to aid development of Alaska village wind power projects. The following wind-diesel system configurations were modeled for this conceptual design report. A one-line diagram of this proposed system is presented in Appendix D.

Modeled wind-diesel configurations

Turbine	No. Turbines	Installed kW	Tower Type	Hub Height (meters)
Aeronautica AW/Siva 250	3	750	Monopole	30
EWT DW 54-900	1	900	Monopole	50
Northern Power NPS 360-39	2	720	Monopole	30
Vestas V27	4	900	Monopole	32

Modeling assumes that wind turbines constructed in Wainwright will operate in parallel with the diesel generators. Excess energy presumably will serve thermal loads via a secondary load controller and electric boiler that will augment the existing jacket water heat recovery system and is modeled as such in the technical analysis of this report (although not in the economic analysis).

Although not considered in this report, deferrable electric and/or remote node thermal loads could be served with excess system energy. This possibility will be considered during the design phase of the project.

Technical modeling assumptions

Operating Reserves	
Load in current time step	10%
Wind power output	50% (diesels always on)
Fuel Properties (no. 2 diesel for powerplant)	
Heating value	46.8 MJ/kg (140,000 BTU/gal)
Density	830 kg/m^3 (6.93 lb./gal)
Fuel Properties (no. 1 diesel to serve thermal loads)	
Heating value	44.8 MJ/kg (134,000 BTU/gal)
Density	830 kg/m^3 (6.93 lb./gal)
Diesel Generators	
Efficiency	14.6 kWh/gal (NSB data)
Minimum load	15%
Schedule	Optimized
Wind Turbines	
Net capacity factor	85% (adjusted by reducing mean wind speed in Homer software)
Turbine hub height	As noted
Wind speed	6.96 m/s at 30 m level at met tower site; wind speed scaled to 6.41 m/s for 85% turbine net AEP
Density adjustment	Density not adjusted

Energy Loads	
Electric	14,253 kWh/day mean annual electrical load
Thermal	18,528 kWh/day mean annual via recovered heat loop
Fuel oil boiler efficiency	85%
Electric boiler efficiency	100%

Model Results

The Site B wind resource is presumed to be identical to that measured at the met tower site. Given the flat, featureless terrain between the met tower and Site B, this is a reasonable assumption although orographic wind modeling may indicate some variability between the met tower location and Site B. Site B likely is not height restricted, hence larger turbines and/or higher hub heights are possible. Note that turbine energy production is modeled at 85 percent net.

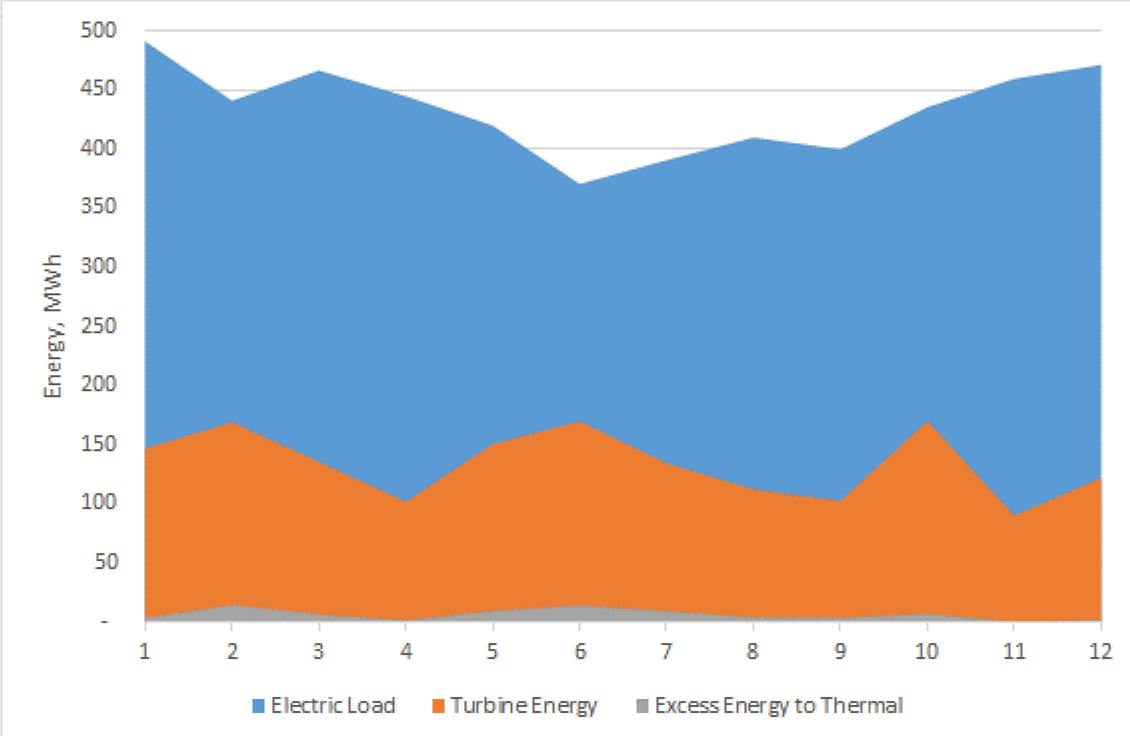
AW/Siva 250, three (3) turbines, 30 m hub height

This configuration models three AW/Siva 250 wind turbines at Wainwright Site B at a 30 meter hub height and generating 85 percent of maximum annual energy production.

Energy table, three AW/Siva 250, 85% net AEP

Month	Electric Load	Wind Energy Generated	Total Energy Generated	Turbine Energy to E. Load	Wind Penetration	Excess Energy to Thermal	Excess Energy to Thermal
	kWh	kWh	kWh	kWh	%	kWh	%
1	491,387	147,179	495,117	143,449	29.7%	3,730	0.7%
2	441,134	169,366	456,168	154,332	37.1%	15,034	3.0%
3	466,599	135,727	473,558	128,768	28.7%	6,959	1.2%
4	444,902	102,114	446,968	100,049	22.8%	2,066	0.4%
5	420,044	150,834	429,876	141,003	35.1%	9,832	2.0%
6	370,607	170,007	385,201	155,412	44.1%	14,595	3.2%
7	390,843	134,610	400,543	124,910	33.6%	9,701	2.0%
8	409,943	112,568	414,387	108,123	27.2%	4,445	0.9%
9	400,051	102,701	404,054	98,699	25.4%	4,003	0.8%
10	435,544	170,399	443,147	162,795	38.5%	7,603	1.5%
11	459,540	90,320	460,127	89,733	19.6%	587	0.1%
12	471,389	122,258	473,680	119,966	25.8%	2,291	0.4%
Annual	5,201,982	1,608,084	5,282,827	1,527,239	30.4%	80,845	1.3%

Chart, three AW/Siva 250's



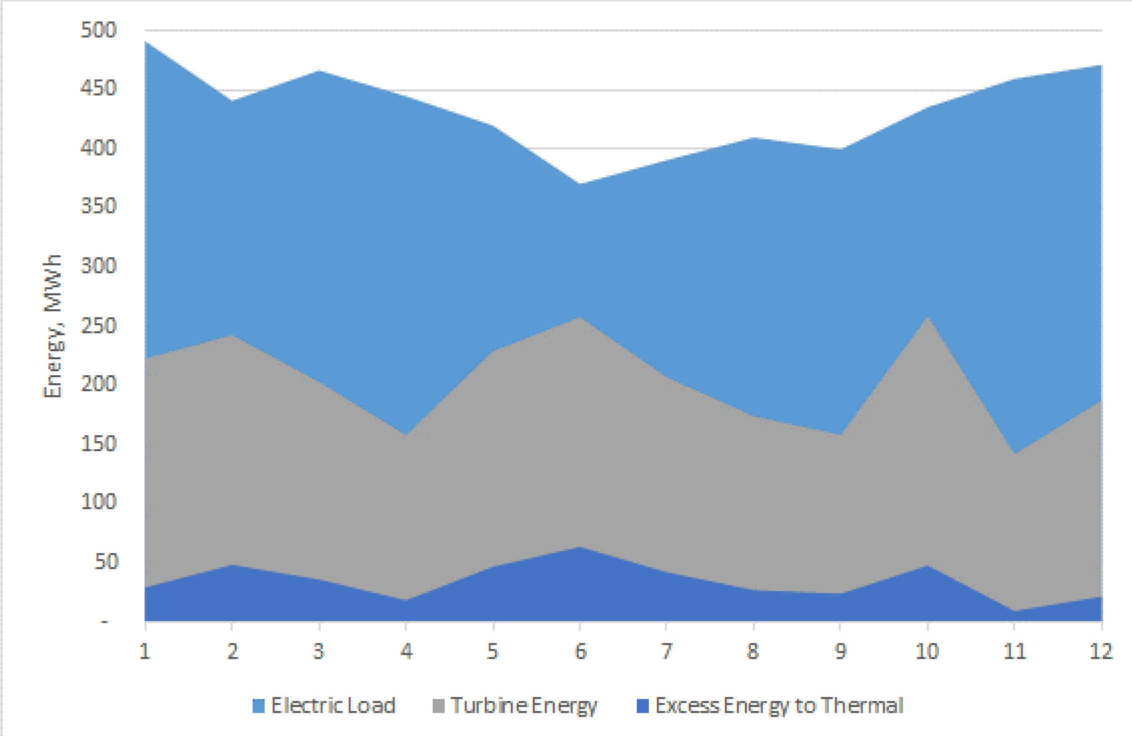
EWT DW 54-900, one (1) turbine, 50 m hub height

This configuration models one EWT DW 54-900 wind turbine at Wainwright Site B at a 50 meter hub height and generating 85 percent of maximum annual energy production.

Energy table, one DW 54-900, 85% net AEP

Month	Electric Load kWh	Wind Energy Generated kWh	Total Energy Generated kWh	Turbine Energy to E. Load kWh	Wind Penetra-tion %	Excess Energy to Thermal kWh	Excess Energy to Thermal %
1	491,387	223,127	520,913	193,601	42.8%	29,526	4.4%
2	441,134	243,114	489,775	194,473	49.6%	48,641	8.1%
3	466,599	203,338	502,925	167,012	40.4%	36,326	5.4%
4	444,902	158,516	463,509	139,909	34.2%	18,607	3.0%
5	420,044	229,494	467,116	182,423	49.1%	47,071	7.5%
6	370,607	258,198	434,451	194,353	59.4%	63,844	10.8%
7	390,843	207,376	433,241	164,978	47.9%	42,398	7.0%
8	409,943	174,391	437,259	147,075	39.9%	27,316	4.4%
9	400,051	158,666	424,266	134,450	37.4%	24,215	3.9%
10	435,544	259,027	483,618	210,953	53.6%	48,074	7.5%
11	459,540	142,389	469,183	132,746	30.3%	9,643	1.6%
12	471,389	187,881	493,210	166,059	38.1%	21,822	3.4%
Annual	5,201,982	2,445,518	5,619,466	2,028,034	43.5%	417,484	5.6%

Chart, one DW 54-900



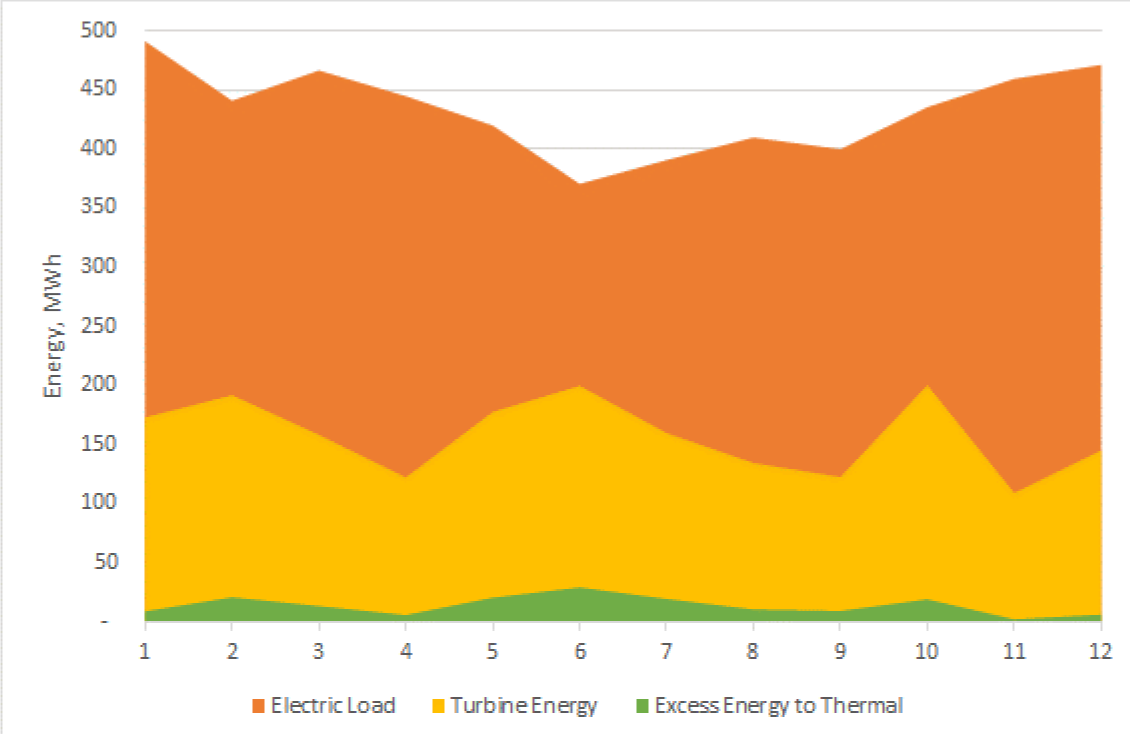
Northern Power NPS 360-39, two (2) turbines, 30 m hub height

This configuration models two Northern Power Systems NPS 360-39 wind turbines at Wainwright Site B at a 30 meter hub height and generating 85 percent of maximum annual energy production.

Energy table, two NPS 360-39's, 85% net AEP

Month	Electric Load	Wind Energy Generated	Total Energy Generated	Turbine Energy to E. Load	Wind Penetra-tion	Excess Energy to Thermal	Excess Energy to Thermal
	kWh	kWh	kWh	kWh	%	kWh	%
1	491,387	173,146	500,699	163,834	34.6%	9,312	1.6%
2	441,134	191,969	462,368	170,735	41.5%	21,234	4.1%
3	466,599	158,459	480,340	144,719	33.0%	13,741	2.4%
4	444,902	122,521	451,113	116,310	27.2%	6,211	1.2%
5	420,044	177,802	440,863	156,984	40.3%	20,818	3.9%
6	370,607	199,860	400,160	170,306	49.9%	29,554	5.8%
7	390,843	160,000	410,670	140,173	39.0%	19,827	3.8%
8	409,943	134,757	420,836	123,864	32.0%	10,893	2.1%
9	400,051	122,845	409,671	113,225	30.0%	9,620	1.8%
10	435,544	200,414	455,051	180,907	44.0%	19,507	3.6%
11	459,540	109,335	462,160	106,715	23.7%	2,620	0.5%
12	471,389	145,397	478,040	138,745	30.4%	6,652	1.2%
Annual	5,201,982	1,896,504	5,371,971	1,726,515	35.3%	169,989	2.7%

Chart, two NPS 360-39's



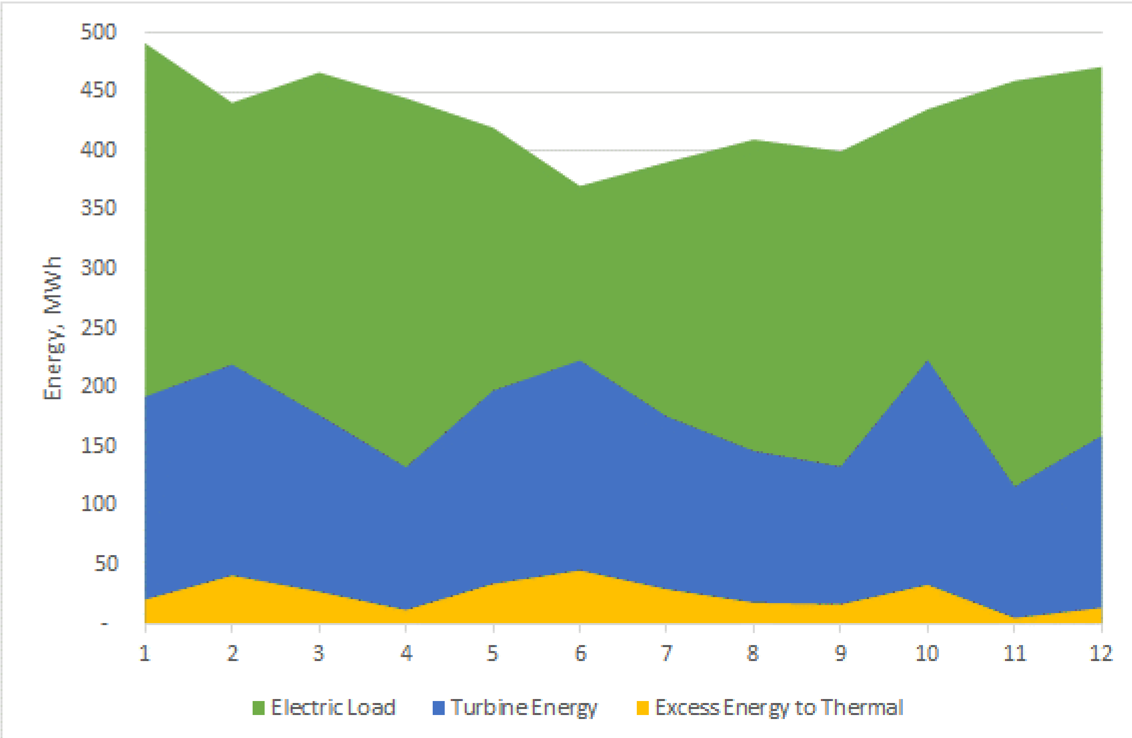
Vestas V27, four (4) turbines, 32 m hub height

This configuration models three Vestas V27 wind turbines at Wainwright Site B at a 32 meter hub height and generating 85 percent of maximum annual energy production.

Energy table, four V27's, 85% net AEP

Month	Electric Load	Wind Energy Generated	Total Energy Generated	Turbine Energy to E. Load	Wind Penetra-tion	Excess Energy to Thermal	Excess Energy to Thermal
	kWh	kWh	kWh	kWh	%	kWh	%
1	491,387	192,705	512,464	171,627	37.6%	21,078	3.2%
2	441,134	219,814	482,571	178,377	45.6%	41,437	7.0%
3	466,599	177,009	494,285	149,322	35.8%	27,686	4.2%
4	444,902	132,878	457,220	120,560	29.1%	12,318	2.0%
5	420,044	197,569	454,422	163,191	43.5%	34,377	5.7%
6	370,607	223,267	416,366	177,508	53.6%	45,759	8.1%
7	390,843	175,827	420,647	146,022	41.8%	29,805	5.1%
8	409,943	146,692	428,461	128,174	34.2%	18,519	3.1%
9	400,051	133,556	417,080	116,527	32.0%	17,029	2.9%
10	435,544	223,630	469,218	189,955	47.7%	33,674	5.5%
11	459,540	116,594	465,092	111,042	25.1%	5,552	1.0%
12	471,389	159,552	485,526	145,414	32.9%	14,138	2.2%
Annual	5,201,982	2,099,093	5,503,354	1,797,721	38.1%	301,372	4.1%

Chart, four V27's



Economic Analysis

Modeling assumptions are detailed in the table below. Many assumptions, such as project life, discount rate, operations and maintenance (O&M) costs, etc. are AEA default values. Other assumptions, such as diesel overhaul cost and time between overhaul are based on general rural Alaska power generation experience. The base or comparison scenario is the Wainwright powerplant with its present configuration of diesel generators and the existing thermal loads connected to the heat recovery loop.

Fuel Cost

A fuel price of $5.49/gallon ($1.45/Liter) was chosen for the initial HOMER analysis by reference to *Alaska Fuel Price Projections 2013-2035*, prepared for Alaska Energy Authority by the Institute for Social and Economic Research (ISER), dated June 30, 2103 and the *2013_06_R7Prototype_final_07012013* Excel spreadsheet, also written by ISER. The $5.49/gallon price reflects the average value of all fuel prices between the 2015 (the assumed project start year) fuel price of $4.67/gallon and the 2034 (20 year project end year) fuel price of $6.47/gallon using the medium price projection analysis with an average CO_2-equivalent allowance cost of $0.58/gallon included.

By comparison, the fuel price for Wainwright reported to Regulatory Commission of Alaska for the 2012 PCE report is $4.28/gallon ($1.13/Liter), without inclusion of the CO_2-equivalent allowance cost. Assuming a CO_2-equivalent allowance cost of $0.40/gallon (ISER *Prototype* spreadsheet, 2013 value), the 2012 Wainwright fuel price was $4.68/gallon ($1.23/Liter).

Heating fuel displacement by excess energy diverted to thermal loads is valued at $6.53/gallon ($1.73/Liter) as an average price for the 20 year project period. This price was determined by reference to the *2013_06_R7Prototype_final_07012013* Excel spreadsheet where heating oil is valued at the cost of diesel fuel (with CO_2-equivalent allowance cost) plus $1.05/gallon, assuming heating oil displacement between 1,000 and 25,000 gallons per year.

Fuel cost table, CO_2-equivalent allowance cost included

ISER med. projection	2015 (/gal)	2034 (/gal)	Average (/gallon)	Average (/Liter)
Diesel Fuel	$4.67	$6.47	$5.49	$1.45
Heating Oil	$5.73	$7.51	$6.53	$1.73

Wind Turbine Project Costs

Construction cost for wind turbine installation and integration with the diesel power plant will be accurately estimated during the design phase of the project. Project costs are estimated in this conceptual design report in order to provide comparative valuation. The client is strongly encouraged not to select the wind turbine configuration option based on cost alone, especially the tentative costs presented in this conceptual design report, as other factors may be more important from an operational, maintenance, integration, and support point of view.

Economic modeling assumptions

Economic Assumptions	
Project life	20 years (2014 to 2033)
Discount rate for NPV	3% (ISER spreadsheet assumption)
System fixed capital cost (plant upgrades required to accommodate wind turbines)	Included in turbine project cost
Fuel Properties (no. 2 diesel for powerplant)	
Price (20 year average; ISER 2013, medium projection plus social cost of carbon)	$5.49/gal ($1.45/Liter)
Fuel Properties (no. 1 diesel to serve thermal loads)	
Price (20 year average; ISER 2013, medium projection plus social cost of carbon)	$6.53/gal ($1.73/Liter)
Diesel Generators	
Generator capital cost	$0 (already installed)
O&M cost	$0.02/kWh (ISER spreadsheet assumption)
Efficiency	13.8 kWh/gal (Homer model)
Wind Turbines	
Net capacity factor	85% (adjusted by reducing mean wind speed in Homer software)
O&M cost	$0.049/kWh (ISER spreadsheet assumption)

Wind Turbine Costs

Config-uration	No. Turbs	Wind Capacity (kW)	Turbine	Freight	Install	Civil	Distribu-tion	Power-plant	Project Cost	Cost/kW
			Cost Estimate (in $millions)							
AW/Siva 250	3	750	1.80	0.70	1.60	1.75	0.65	0.30	6.80	$ 9,100
EWT 54-900	1	900	1.85	0.70	1.80	1.50	0.65	0.40	6.90	$ 7,700
NPS 360-39	2	720	1.45	0.70	1.80	1.75	0.65	0.30	6.65	$ 9,200
V27	4	900	1.60	0.70	1.50	2.00	0.65	0.30	6.75	$ 7,500

Modeling Results

The reader is cautioned to note that the economic benefit-to-cost ratios calculated by the ISER method **do not** account for heat loss from the diesel engines due to reduced loading and subsequent impact on heating fuel usage to serve the thermal loads, hence bias high at high modeled wind penetrations. ISER cost modeling assumptions are noted above or are discussed in the 2013_06_R7Prototype_final_ 07012013 Excel spreadsheet. Net annual energy production of the wind turbines was assumed at 85 percent to reflect production losses due to operations and maintenance down time, icing loss, wake loss, hysteresis, etc.

Economic comparison table of Wainwright wind turbine options

Config-uration	Wind Turbine Capacity (kW)	Project Cost	NPV Benefits	NPV Costs	B/C ratio	Diesel Fuel Saved (gal/yr)	Heat Oil Saved (gal/yr)	Petroleum Fuel Saved (gal/yr)
		(in $ millions)						
AW/Siva 250	750	6.80	7.27	6.04	1.20	104,600	2,100	106,700
EWT 54-900	900	6.90	10.35	6.13	1.69	138,900	10,700	149,600
NPS 360-39	720	6.65	8.39	5.91	1.42	118,300	4,300	122,600
V27	900	6.75	9.04	6.00	1.51	123,500	7,700	131,200

Data Analysis Uncertainty

There are a number of concerns and potential problems with data used for modeling in this report. Chief among them is that the Wainwright powerplant data are manually-collected log readings, *not* computer-calculated averaged power per hour as one might conclude by reviewing North Slope Borough's *2013_Wainwright_PPOR* file. While manually-collected logs are desirable from an operational perspective, manual logs are not suitable for modeling as they are only a brief "snapshot" once per hour of the load and are generally unrepresentative, sometimes dramatically so, of actual average load demand during the time period of the log entry.

Note that the manually-collected logs likely account for the odd occurrences of very low electrical loads for a particular hour that are bracketed by much higher loads on either side. In reality this load variation most likely did not occur, but identifying and correcting every questionable occurrence in an 8,760 line data set is extremely tedious and not necessary for this analysis.

The thermal load appears to be reasonably well documented, but the data is four years old. Additionally, the RSA Engineering report was structured such that actual load demand is not readily apparent. This might be a consideration during design should North Slope Borough wish to consider much higher wind penetrations where thermal offset would be considerably larger than modeled (note that high penetration with significant excess energy to thermal would occur with one EWT 54-900 turbine; numbers of other turbines must be increased to yield similar results).

Project costs are estimated in this conceptual design report and will be determined with greater accuracy during the design phase of the project.

Discussion

For this conceptual design report, only proven and robust wind turbines were considered for evaluation, hence any of the evaluated configurations can be designed and operated to meet expectations of high performance and reliability. Integration requirements will vary depending on the type of electrical generator in the turbine (synchronous vs. asynchronous), inverter-conditioning, soft-start or other similar grid stability control features, VAR support if necessary, minimum loading levels of the diesel generators as a percentage of the electric load, secondary load controller resolution and response time, among others. These design elements are beyond the scope of this conceptual design project, but the technology is mature enough to be assured that the wind turbines operating in a medium penetration/non-storage mode in Wainwright are controllable.

With these issues in mind, the primary deciding factors for selection of wind turbine(s) for Wainwright will be cost, reliability, aesthetics, redundancy, support, and commonality.

Cost

Note that the cost estimates in this report were not produced with the same level of precision and accuracy as will occur during the design phase and so should be treated with a substantial level of caution. Also note that many cost parameters such as operations and maintenance costs over the life of the project are estimated using Alaska Energy Authority default values and may not be realistic for any particular turbine configuration option. For this reason the benefit-to-cost ratios indicated in the preceding table should not be ranked nor compared. The point of including the table is to indicate that per the parameters of this analysis, all four turbine options exhibit beneficial economic potential for North Slope Borough and the community of Wainwright.

Reliability

Turbine reliability can be obtained from manufacturer data, third party reviews, and utility experience. Even with a great warranty and promises of strong manufacturer support, robust and reliable wind turbines are highly desirable. Wainwright is an isolated community and expensive to visit, so it is desirable to install equipment where the likelihood of nagging maintenance issues are minimal. All warranty and maintenance support periods eventually end, and North Slope Borough will want to be assured that the turbines they purchase will serve them well in the future.

Aesthetics

This is a highly subjective consideration that undoubtedly will elicit a number of strong and conflicting opinions. Ultimately, Wainwright residents must collectively agree on the aesthetic impact of wind turbines in their community. Simply put, wind turbines will have a visual impact in Wainwright and will easily be the highest and most dominating structure(s) for miles around. Which is preferable: one large, very high turbine or two or more smaller, clustered turbines? This is a difficult question for most people to answer in the abstract because one must imagine wind turbines at Site B where at present the landscape is bare and nearly featureless. Software modeling that superimposes virtual wind turbine(s) onto the Google Earth image of Wainwright might prove beneficial for the discussion.

Redundancy

A single wind turbine would be redundant in the sense that diesel generation will meet electrical load demand should the turbine be off-line for maintenance or a fault condition. On the other hand, a single wind turbine is not redundant with respect to wind generation. Should the turbine be out of service for an extended period of time, wind energy will not be generated during the outage.

Support

Manufacturer warranty and support will be a primary consideration of North Slope Borough given its responsibility as electrical utility for Wainwright. The Borough must have confidence that the turbine manufacturer and/or its representatives will be available throughout the life of the project. This is a matter of trust and ultimately a value that North Slope Borough must determine for itself.

Commonality

This is a practical consideration for North Slope Borough. There are four Borough village wind projects presently entering the design phase: Point Hope, Point Lay, Wainwright, and Kaktovik. In the related Kaktovik project, North Slope Borough arranged a manufacturer site visit report in March 2014 to Halus Power Systems in California (remanufacturer of Vestas wind turbines), Aeronautica Windpower in Massachusetts, and Northern Power Systems in Vermont. Objectives of this trip were to meet company representatives, establish relationships, and assess the desirability and potential of each as the “fleet turbine” provider for the Borough.

There are many desirable aspects of a fleet turbine – whether a single turbine model or a family of models – that would be attractive to North Slope Borough. These include a single supplier and point of contact, a common control system for all turbines in the fleet, common parts, and utility and village technicians that learn to service only one type of turbine, not two or more.

On the other hand, given the variability in electrical load profile and site size and height constraints, no one turbine manufacturer addressed in this conceptual design report provides the perfect solution for all four North Slope Borough villages. It may be more optimal to install a turbine(s) from one manufacturer in one village and turbine(s) from a different manufacturer in another village.

Turbine Recommendation

A number of factors presented in the discussion section above are the province of North Slope Borough and/or the community of Wainwright to decide, such as aesthetic considerations and confidence in manufacturer guarantees and proffered support. These factors and others will influence the turbine configuration decision for the design phase of the project. Nevertheless and with these issues in mind, the configuration of three Northern Power Systems NPS 360-39 wind turbines (with the possibility of additional turbines in the future) is recommended by WHPacific Solutions Group and V3 Energy as the preferred option for wind power development in Wainwright.

WHPacific Solutions Group and V3 Energy recommend a configuration of four Vestas V27 wind turbines as an alternate option, and a configuration of three AW/Siva 250 wind turbines as a second alternate option, but less is known about the Siva turbine compared to Vestas, hence some hesitancy about this option at the present time.

These recommendations are based on the following considerations:

- Cost – Preliminary cost modeling indicates that the EWT DW 900, NPS 360-39, and V39 options are relatively equal with respect to life-cycle economic benefit. The AW/Siva 250 option appears to have a lower life-cycle economic benefit, but still positive.

- Reliability – All turbine options presented in this report are considered to be reliable machines with proper maintenance and support.

- Aesthetics – The NPS 360-39 is offered only on a relatively low 28.5 meter tower (for a 30 meter hub height), minimizing the visual impact of this turbine compared to the others. The alternate turbines, however, are available on at least 40 meter towers on the low end, so their visual impact is not much greater.

- Redundancy – With respect to redundancy, WHPacific Solutions Group and V3 Energy recommend two or more wind turbines for Wainwright. Despite the admirably excellent availability history of the EWT wind turbine in their typical grid-connected installations, it should be recognized that all wind turbines considered in this conceptual design report have excellent availability histories when grid-connected.

  As a general rule though, wind turbine availability has been lower in Alaska village wind-diesel systems than in grid-connected applications. There are many reasons for this, principally related to integration and operational factors. Some of these issues can be mitigated with careful design and planning, but an expectation of utility-experience wind turbine availability is unrealistic in rural Alaska. With this reality in mind, installing at least two wind turbines enables continuity of wind power production should one turbine be out of service for an extended period of time.

- Support – All four turbine manufacturers evaluated in this conceptual design report are highly regarded companies with extensive depth and capability to provide warranty and continuing support over time with both factory personnel and Alaska-based representatives. In addition, all four companies will train North Slope Borough personnel to operate and maintain the turbines.

- Commonality – Considering the electric load demand and wind turbine site constraints in Point Hope, Point Lay, Wainwright and Kaktovik (North Slope Borough's companion wind power project villages), only the Aeronautica, Northern Power Systems, and Vestas family of turbines can be used in all four communities.

It is the opinion of WHPacific Solutions Group and V3 Energy LLC that North Slope Borough will find it less demanding to manage one type of wind turbine among several village projects than two or more turbine types, other factors aside.

Single Turbine Option

The EWT DW 54-900 is an admirable wind turbine and highly suitable for Wainwright, but it has a very large energy generation capacity for medium penetration mode (although it can be setpoint limited for reduced output) and recommending it would counter the values of redundancy and commonality expressed above. Although WHPacific Solutions Group and V3 Energy believe that North Slope Borough would be better served with redundant wind turbine capacity in their project communities, this is not strictly necessary for a successful wind project. It should be noted that EWT offers performance guarantees for their turbines that mitigates the risk of a single turbine application which North Slope Borough may wish to consider.

Commonality of wind turbines for all four planned wind power projects (Point Hope, Point Lay, Wainwright, and Kaktovik), however, is considered to be in the Borough's best interests and hence the recommendation of a wind turbine that will be suitable for all four communities. Should North Slope Borough be willing to consider two turbine types, the EWT DW 54-900 may be the best choice for Wainwright after all.

Wind Turbine Layout

Site B boundaries are not defined at present, but available land for wind turbine layout is expected to be fairly unrestricted. The image below shows two Northern Power Systems NPS 360-39 wind turbines in a northwest-to-southeast alignment with four rotor diameter (approximately 160 meters) separation. This is within the three to five rotor diameter separation generally recommended for turbine array design. Precise turbine locations with attendant wake loss (array efficiency) calculations will be modeled during the design phase of this project after site and turbine selections.

Refer to Appendix E for drawings of the existing electrical distribution system and necessary expansion to connect wind turbines located at Site B. As indicated, approximately 1.5 miles of new 12.47 kV distribution is required. Should wind turbines be located at Site A, 0.5 miles of new 12.47 kV distribution would be necessary, one-third that required for Site B. On the other hand, development of Site A would require construction of a 0.25 mile access road, which is longer than for Site B.

Proposed NPS 360-39 turbine layout, Wainwright Site B

Data Collection Recommendation

During the design phase of the Wainwright wind power project, North Slope Borough may want to consider an enhanced power plant monitoring and data collection effort to obtain average and transient load and other data not presently available. To capture transient behavior, highly granular data (one second or less averaging time) is most desirable. Data of this nature is valuable for the design process and significantly reduces the risk of design errors and/or omissions resulting from unknown or unrecognized behavior of existing system components.

Project Wind Penetration Consideration

This conceptual design report focused on four wind turbine configuration options that achieved approximately 35 percent wind power penetration, except for the EWT DW 900, which is higher. During design, presuming that the turbine type has been selected, North Slope Borough may want to consider the benefits and cost implications of additional wind turbine capacity; for instance, 50 percent-plus average wind power penetration. This evaluation can be achieved with Homer software and other modeling tools and may yield in a more optimal and beneficial wind-diesel power system for the community of Wainwright than the configurations presented in this report. Note, however, that increasing wind power penetration increases system complexity; these two factors are interrelated and cannot be uncoupled.

Appendix A – FAA's Notice Criteria Tool, Site A

Mail Processing Center
Federal Aviation Administration
Southwest Regional Office
Obstruction Evaluation Group
2601 Meacham Boulevard
Fort Worth, TX 76137

Aeronautical Study No.
2011-WTW-9177-OE

Issued Date: 08/19/2011

Kent Grinage
North Slope Borough
P.O. Box 69
Barrow, AK 99723

**** NOTICE OF PRESUMED HAZARD ****

The Federal Aviation Administration has conducted an aeronautical study under the provisions of 49 U.S.C., Section 44718 and if applicable Title 14 of the Code of Federal Regulations, part 77, concerning:

Structure:	Wind Turbine AIN Wind Turbine Site A
Location:	Wainwright, AK
Latitude:	70-38-44.96N NAD 83
Longitude:	160-00-49.41W
Heights:	195 feet above ground level (AGL)
	238 feet above mean sea level (AMSL)

Initial findings of this study indicate that the structure as described exceeds obstruction standards and/or would have an adverse physical or electromagnetic interference effect upon navigable airspace or air navigation facilities. Pending resolution of the issues described below, the structure is presumed to be a hazard to air navigation.

If the structure were reduced in height so as not to exceed 148 feet above ground level (191 feet above mean sea level), it would not exceed obstruction standards and a favorable determination could subsequently be issued.

To pursue a favorable determination at the originally submitted height, further study would be necessary. Further study entails distribution to the public for comment, and may extend the study period up to 120 days. The outcome cannot be predicted prior to public circularization.

If you would like the FAA to conduct further study, you must make the request within 60 days from the date of issuance of this letter.

See Attachment for Additional information.

NOTE: PENDING RESOLUTION OF THE ISSUE(S) DESCRIBED ABOVE, THE STRUCTURE IS PRESUMED TO BE A HAZARD TO AIR NAVIGATION. THIS LETTER DOES NOT AUTHORIZE CONSTRUCTION OF THE STRUCTURE EVEN AT A REDUCED HEIGHT. ANY RESOLUTION OF THE ISSUE(S) DESCRIBED ABOVE MUST BE COMMUNICATED TO THE FAA SO THAT A FAVORABLE DETERMINATION CAN SUBSEQUENTLY BE ISSUED.

IF MORE THAN 60 DAYS FROM THE DATE OF THIS LETTER HAS ELAPSED WITHOUT ATTEMPTED RESOLUTION, IT WILL BE NECESSARY FOR YOU TO REACTIVATE THE STUDY BY FILING A NEW FAA FORM 7460-1, NOTICE OF PROPOSED CONSTRUCTION OR ALTERATION.

If we can be of further assistance, please contact our office at (907) 271-5863. On any future correspondence concerning this matter, please refer to Aeronautical Study Number 2011-WTW-9177-OE.

Signature Control No: 147442963-148168743 (NPH -WT)

Robert van Haastert
Specialist

Attachment(s)
Additional Information
Map(s)

Additional information for ASN 2011-WTW-9177-OE

ASN 2011-WTW-9177-OE

Abbreviations

VFR - Visual Flight Rules	AGL - Above Ground Level	RWY - runway
IFR - Instrument Flight Rules	MSL - Mean Sea Level	nm - nautical mile
DA - Decision Altitude	MDA - Minimum Decent Altitude	
NEH - No Effect Height	ICA - Initial Climb Area	

Part 77 - Title 14 (CFR) Part 77, Safe, Efficient Use and Preservation of the Navigable Airspace

Our study has disclosed that this proposed wind turbine at 195 AGL / 238 MSL is within protected surfaces at Wainwright (AWI) airport, AK.

At the proposed height, this structure will penetrate this AWI protected airport surface:

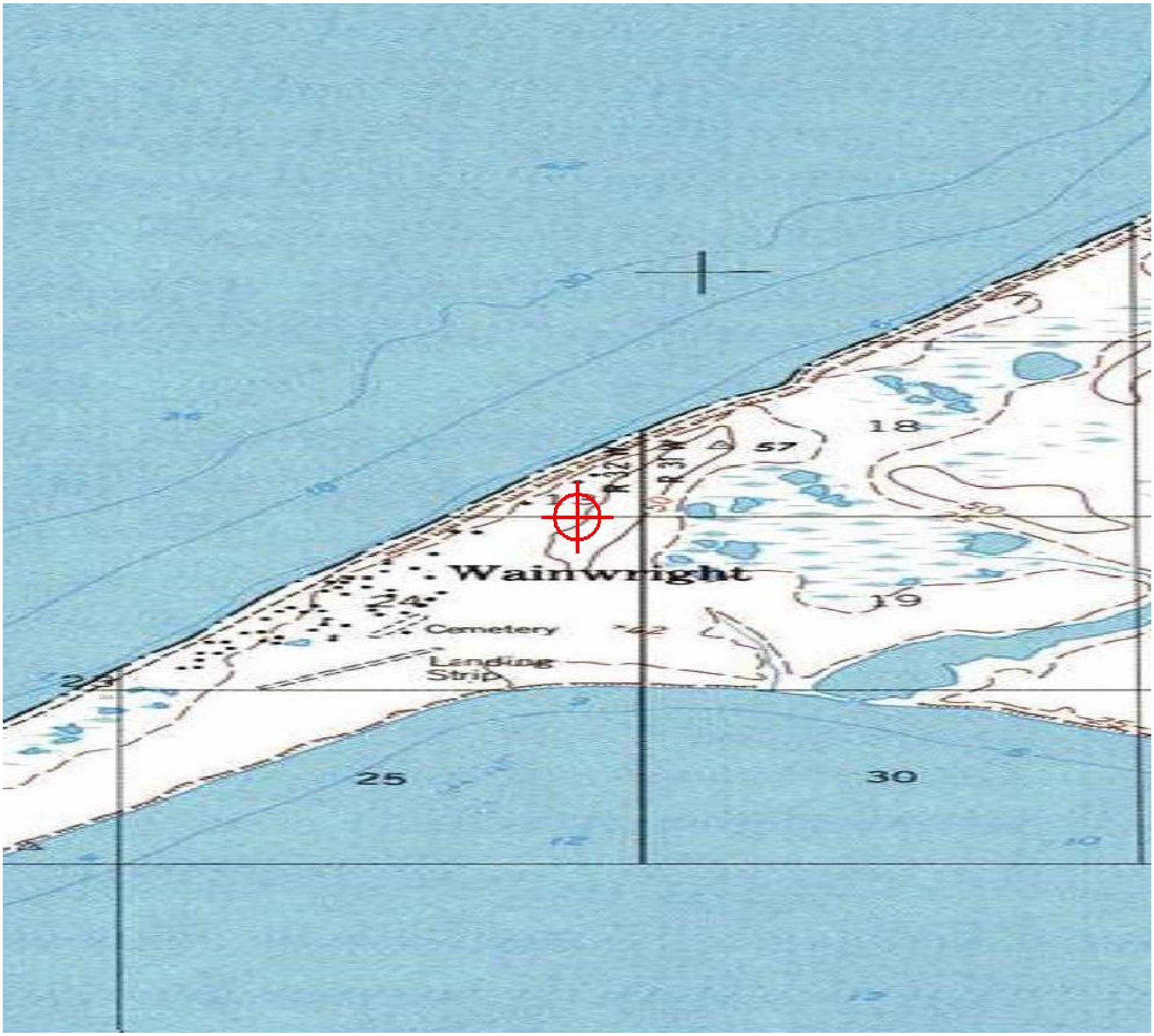
Section 77.19(a) - A height exceeding a horizontal plane 150 feet above the established airport elevation. This would exceed the VFR maneuvering areas for Category A and Category B aircraft (horizontal surface) at AWI by 47 feet

A favorable FAA Determination can be written for a revised 148 AGL/ 191 MSL structure.

Additionally, if the traffic pattern can be restricted entirely south of the airport, then a favorable Determination can be issued at the proposed heights.
If you would like to continue with the original proposed 195 AGL / 238 MSL height, further FAA study will be required. To initiate further FAA study will require notification from you requesting further FAA study. An email request for further FAA study will suffice. Further FAA study will involve a public notice circularization and 37 day comment period. The outcome can not be predicted prior to public circularization. You also have the option at this point to terminate the proposal.

Please email me at Robert.van.Haastert@faa.gov, with your intentions for this aeronautical study.

TOPO Map for ASN 2011-WTW-9177-OE



Appendix B – FAA's Notice Criteria Tool, Site B

Mail Processing Center
Federal Aviation Administration
Southwest Regional Office
Obstruction Evaluation Group
2601 Meacham Boulevard
Fort Worth, TX 76137

Aeronautical Study No.
2011-WTW-9178-OE

Issued Date: 08/19/2011

Kent Grinage
North Slope Borough
P.O. Box 69
Barrow, AK 99723

**** DETERMINATION OF NO HAZARD TO AIR NAVIGATION ****

The Federal Aviation Administration has conducted an aeronautical study under the provisions of 49 U.S.C., Section 44718 and if applicable Title 14 of the Code of Federal Regulations, part 77, concerning:

Structure:	Wind Turbine AIN Wind Turbine Site B
Location:	Wainwright, AK
Latitude:	70-39-26.03N NAD 83
Longitude:	159-58-09.83W
Heights:	195 feet above ground level (AGL)
	244 feet above mean sea level (AMSL)

This aeronautical study revealed that the structure does not exceed obstruction standards and would not be a hazard to air navigation provided the following condition(s), if any, is(are) met:

As a condition to this Determination, the structure is marked/lighted in accordance with FAA Advisory circular 70/7460-1 K Change 2, Obstruction Marking and Lighting, white paint/synchronized red lights - Chapters 4,12&13(Turbines).

It is required that FAA Form 7460-2, Notice of Actual Construction or Alteration, be completed and returned to this office any time the project is abandoned or:

_____ At least 10 days prior to start of construction (7460-2, Part I)
__X__ Within 5 days after the construction reaches its greatest height (7460-2, Part II)

Any height exceeding 195 feet above ground level (244 feet above mean sea level), will result in a substantial adverse effect and would warrant a Determination of Hazard to Air Navigation.

This determination expires on 02/19/2013 unless:

(a) extended, revised or terminated by the issuing office.
(b) the construction is subject to the licensing authority of the Federal Communications Commission (FCC) and an application for a construction permit has been filed, as required by the FCC, within 6 months of the date of this determination. In such case, the determination expires on the date prescribed by the FCC for completion of construction, or the date the FCC denies the application.

NOTE: REQUEST FOR EXTENSION OF THE EFFECTIVE PERIOD OF THIS DETERMINATION MUST BE E-FILED AT LEAST 15 DAYS PRIOR TO THE EXPIRATION DATE. AFTER RE-EVALUATION OF CURRENT OPERATIONS IN THE AREA OF THE STRUCTURE TO DETERMINE THAT NO SIGNIFICANT AERONAUTICAL CHANGES HAVE OCCURRED, YOUR DETERMINATION MAY BE ELIGIBLE FOR ONE EXTENSION OF THE EFFECTIVE PERIOD.

Additional wind turbines or met towers proposed in the future may cause a cumulative effect on the national airspace system. This determination is based, in part, on the foregoing description which includes specific coordinates and heights . Any changes in coordinates will void this determination. Any future construction or alteration requires separate notice to the FAA.

This determination does include temporary construction equipment such as cranes, derricks, etc., which may be used during actual construction of the structure. However, this equipment shall not exceed the overall heights as indicated above. Equipment which has a height greater than the studied structure requires separate notice to the FAA.

This determination concerns the effect of this structure on the safe and efficient use of navigable airspace by aircraft and does not relieve the sponsor of compliance responsibilities relating to any law, ordinance, or regulation of any Federal, State, or local government body.

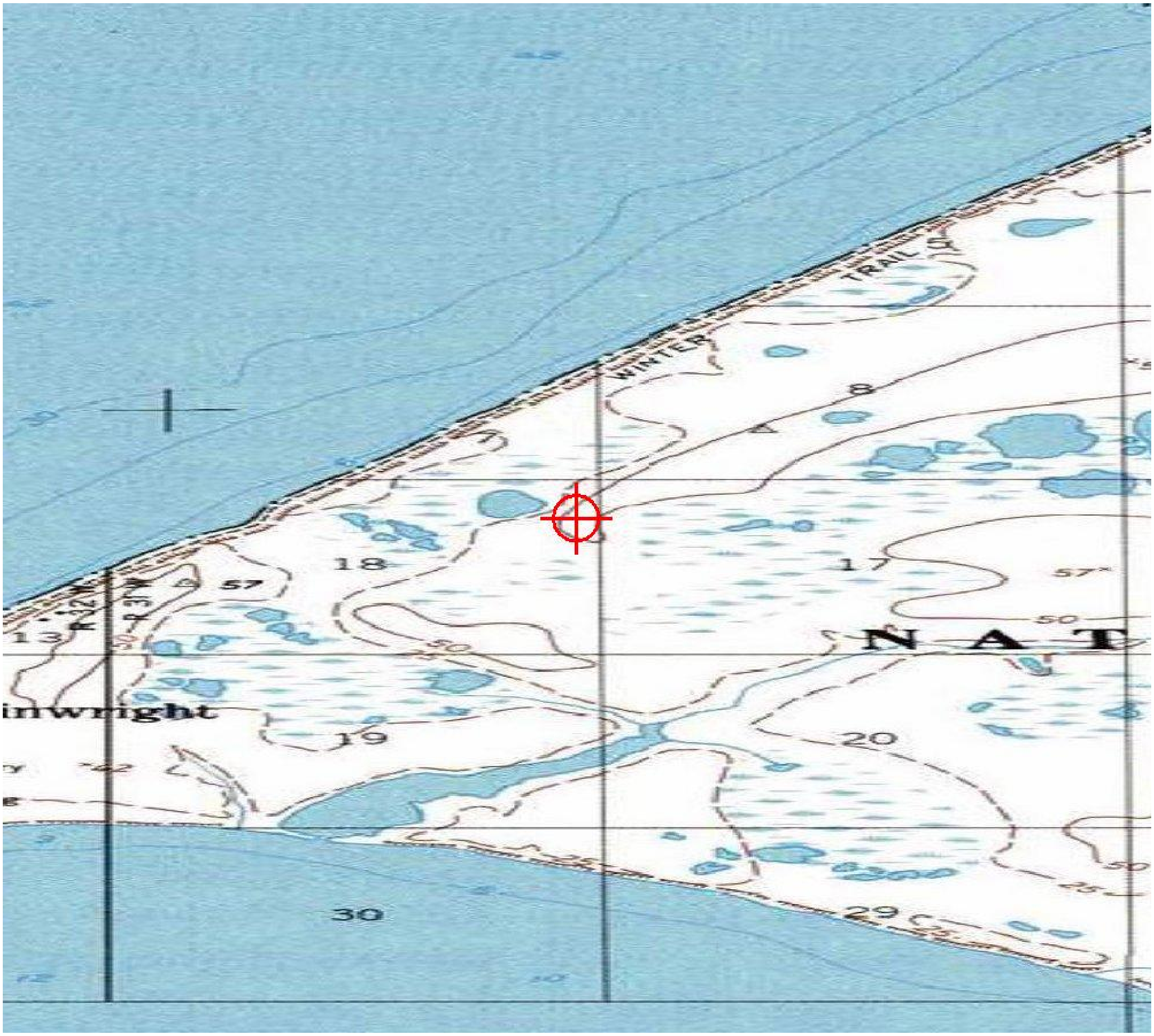
Any failure or malfunction that lasts more than thirty (30) minutes and affects a top light or flashing obstruction light, regardless of its position, should be reported immediately to (800) 478-3576 so a Notice to Airmen (NOTAM) can be issued. As soon as the normal operation is restored, notify the same number.

If we can be of further assistance, please contact our office at (907) 271-5863. On any future correspondence concerning this matter, please refer to Aeronautical Study Number 2011-WTW-9178-OE.

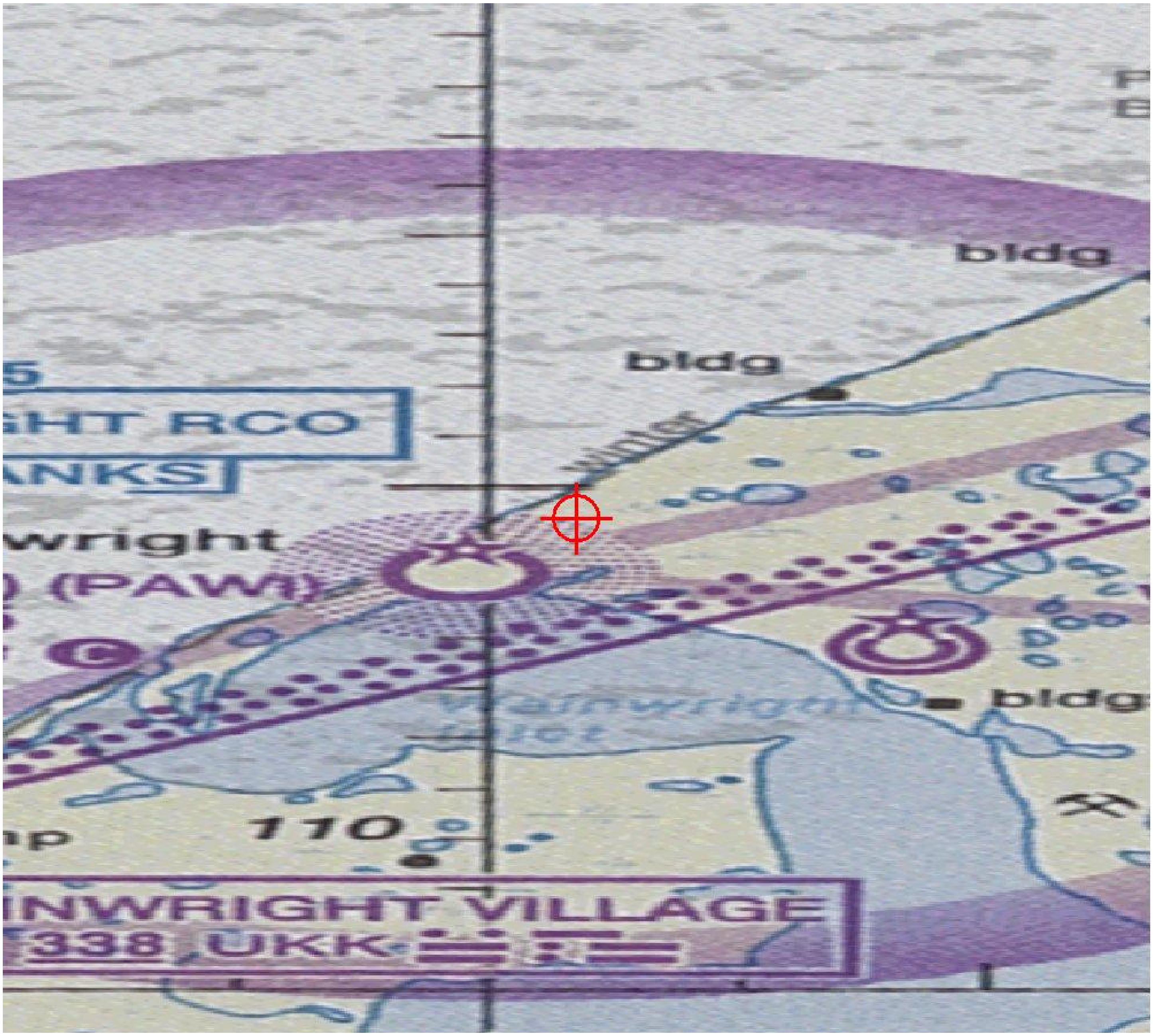
Signature Control No: 147442966-148168755 (DNE -WT)
Robert van Haastert
Specialist

Attachment(s)
Map(s)

TOPO Map for ASN 2011-WTW-9178-OE



Sectional Map for ASN 2011-WTW-9178-OE



Appendix C – Power Grid, Wainwright

REV #	DRAWN BY	APRVD BY	DATE	DESCRIPTION
1	RCK	RCK	04/26/2012	FUSE COORDINATION; UPDATE MAP STANDARDS
2	RCK	RCK	09/11/2012	CORRECTIONS PER UTILITY LINEMAN REDLINES
3	RCK	RCK	12/20/2012	CORRECTIONS/UPDATES PER POLE SURVEY OF 10/2012

TRANSFORMER PROTECTION
AND FUSE COORDINATION

Transformer 12.5Y/7.2kV		Protecting SF Fuse	First Protected Fuse	Second Protected Fuse
1Ø	3Ø			
10	30	1.0	15T	25T
15	45	1.4	15T	25T
25	75	2.1	15T	25T
37.5	112.5	3.5	25T	40T
50	150	5.2	40T	65T
75	225	7.8	65T	100T
100	300	10.4	65T	100T
--	500	14	65T	100T
--	750	21	65T [1]	100T
--	1000	46	100T [2]	140T

SPECIFIC NOTES:

1 Coordinates at fault currents above 4200 amps.

2 Coordinates at fault currents above 4400 amps.

OUTSIDE PLANT INVENTORY

CABLE	UNITS	AERIAL	U.G.
Primary, 1Ø	Lin. Ft.	3541	
Primary, 3Ø	Lin. Ft.	16201	250
Secondary-Main	Lin. Ft.	26707	
Service Drops	Each	177	
TRANSFORMERS	UNITS	POLE MT	PAD MT
15 kVA, 1Ø	Each	12	
25 kVA, 1Ø	Each	17	
37.5 kVA, 1Ø	Each	12	
50 kVA, 1Ø	Each	5	
75 kVA, 3Ø	Each	1	
150 kVA, 3Ø	Each		1
300 kVA, 3Ø	Each		1
750 kVA, 3Ø	Each		1
1 MVA, 3Ø	Each		1

LEGEND

B23L6P1 ⊗ POLE AND NUMBER

Aϕ CONDUCTOR

Bϕ CONDUCTOR

Cϕ CONDUCTOR

SECONDARY MAIN

SERVICE DROP

OPEN

PAD MOUNT TRANSFORMER

25 kVA Bϕ — TRANSFORMER, POLE-MTD, SINGLE-PHASE, kVA SIZE & CONNECTED PHASE

25 kVA(EA) 75 kVA(BANK) 208Y/120V — TRANSFORMER, 3-PHASE, POLE-MTD, kVA EA., kVA BANK, VOLTAGE

GANG SWITCH

NO. OF CUTOUTS; FUSE, RATING AND TYPE — NC = NORMALLY CLOSED, NO = NORMALLY OPEN — CUT-OUT SWITCH - EXISTING

CUT-OUT SWITCH - PROPOSED

FUSE AMPACITY, FUSE TYPE — PRIMARY RISER - 3 PHASE

CONNECTED PHASE — PRIMARY RISER - 1 PHASE

LEGEND FOR POLE NUMBERING SYSTEM:

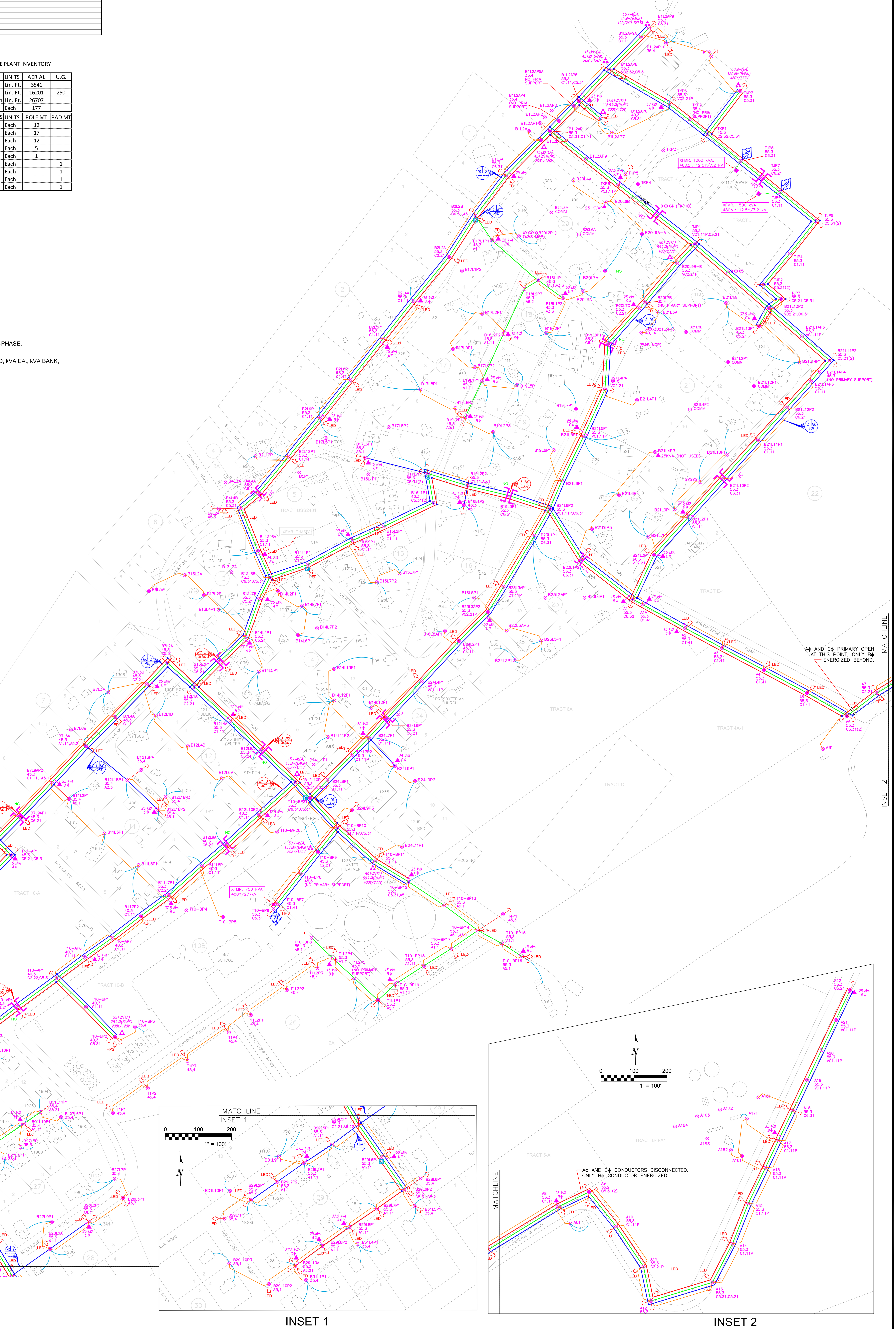
B23L6P1 — BLOCK NO., LOT NO., POLE NO.

T10P2 — TRACT NO., POLE NO.

N

0 100 200 300

1" = 100'

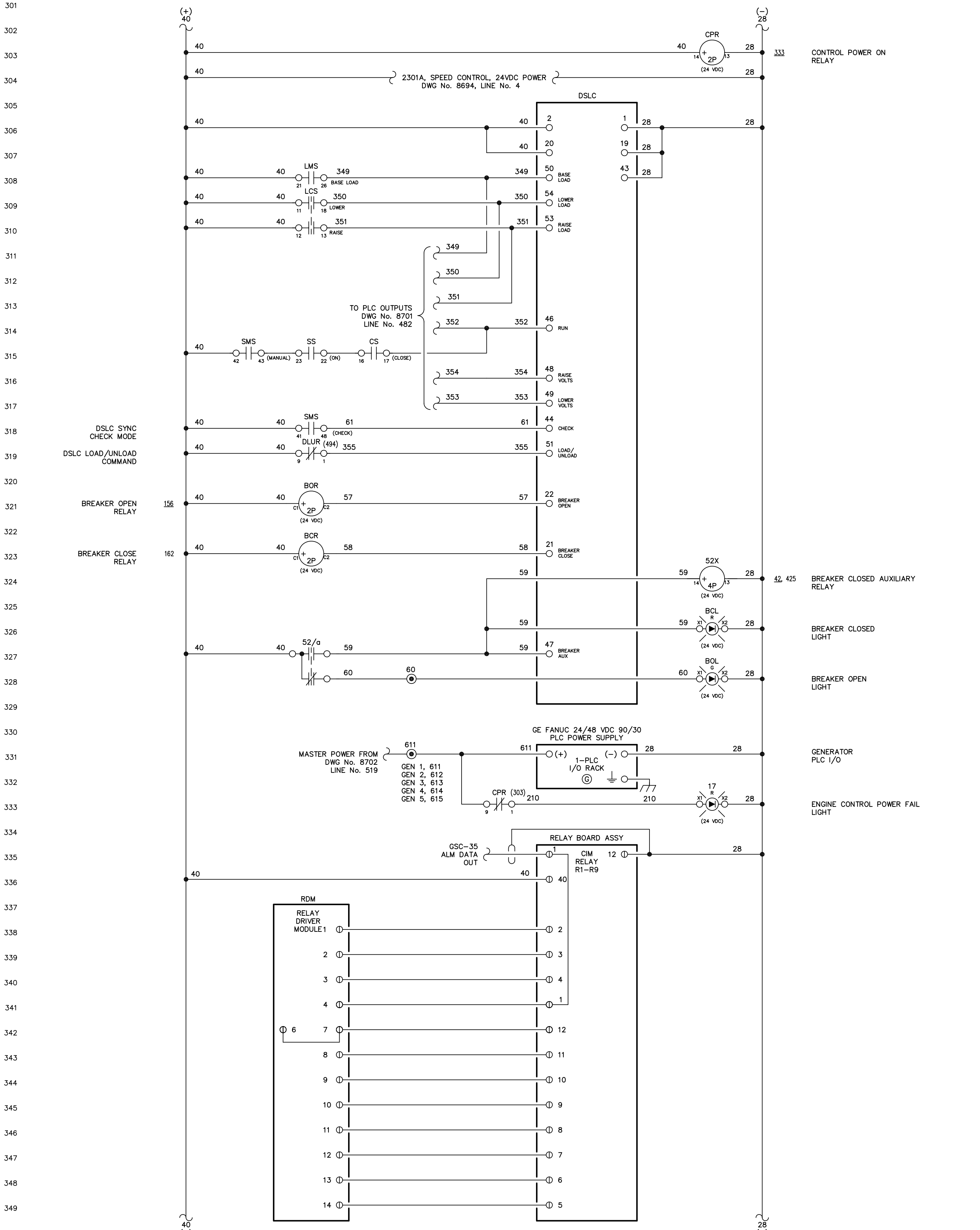


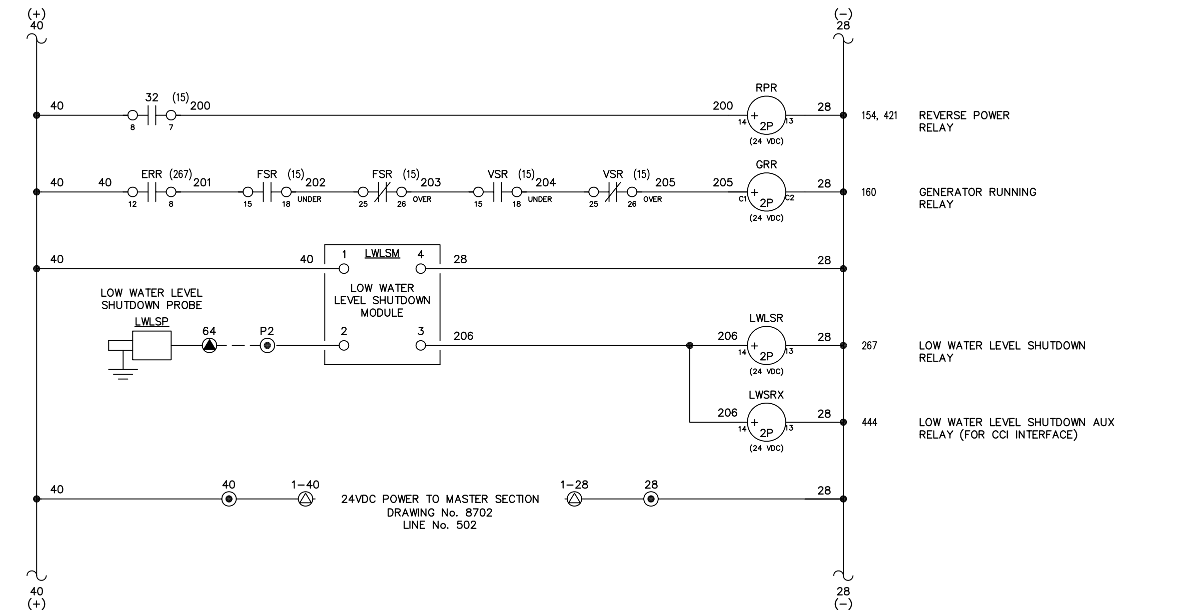
INSET 1

INSET 2

NSB Power Grid
WAINWRIGHT

WHPacific





LEGEND

SYMBOL	DESCRIPTION
◉	TERMINAL LOCATED AT VILLAGE FEEDER 2 SECTION.
⊠	INDICATES TERMINALS LOCATED ON ATB+.
▣	INDICATES TERMINALS LOCATED AT ENGINE.
⊗	INDICATES TERMINALS LOCATED AT BREAKER.
□	INDICATES TERMINALS LOCATED IN GENERATOR JUNCTION BOX.
▲	KULKA TB IN MASTER SECTION BY CCI.
△	INDICATES TERMINALS LOCATED IN MASTER CONTROL SECTION.
◎	INDICATES TERMINALS LOCATED IN SYNC PANEL.
⊙	INDICATES TERMINALS LOCATED IN GENERATOR CONTROL SECTION.

NOTES:

1. ALL CONTROL WIRING TO BE No. 14 AWG, 600 VOLT, TYPE SIS. EXCEPT AS NOTED. CURRENT TRANSFORMER WIRING TO BE No. 12 AWG.
2. SHIELDED WIRE TO BE No. 18 AWG, 300 VOLT TWISTED LINE WITH 100% FOIL COVERAGE.
3. — — — INDICATES FIELD WIRING BY OTHERS.

REV.	DATE	DESCRIPTION	BY
B	12-05-99	REVISED AS INSTALLED	CMS
A	07-16-99	SHOP AS BUILT	CMS

NSB PURCHASE ORDER No. 19993127-000 OP — CONTROLLED POWER JOB No. 4516

TITLE: DC CONTROL, SCHEMATIC DIAGRAM

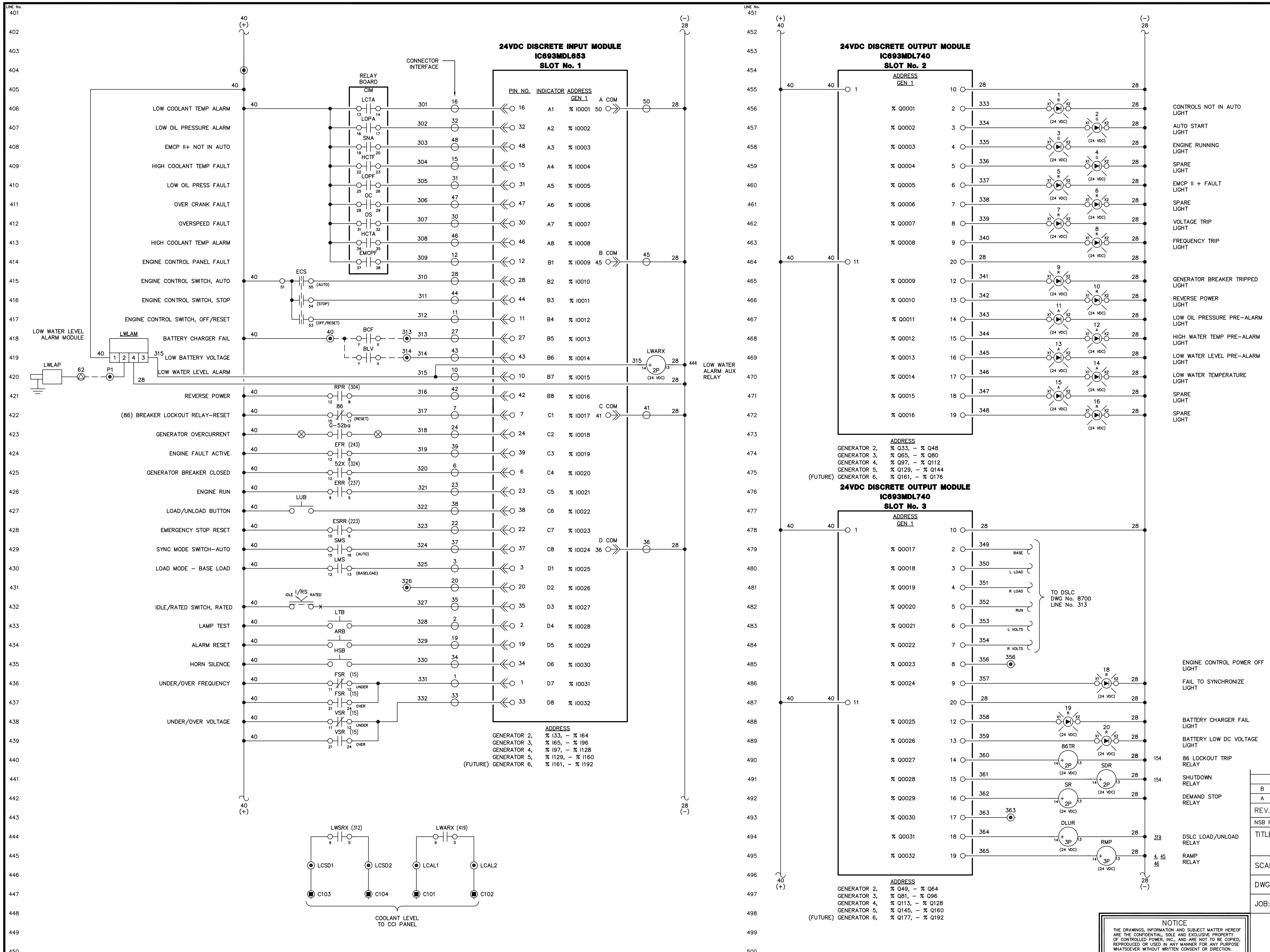
CPI DWG No. 8700

SCALE: NONE	DATE: 06-21-99	DWN. BY: GPN
DWG. No: 8700	SHEET: 1 OF 1	CKD. BY: DLB

JOB: WAINWRIGHT POWER PLANT

NORTH SLOPE BOROUGH
P.O. BOX 69
Barrow, Alaska 99723
(907)852-2611

Plot date: 2013/7/11 – 13:55



LEGEND

SYMBOL	DESCRIPTION
◉	TERMINAL LOCATED AT VILLAGE FEEDER 2 SECTION.
⊠	INDICATES TERMINALS LOCATED ON ATB+.
▣	INDICATES TERMINALS LOCATED AT ENGINE.
⊗	INDICATES TERMINALS LOCATED AT BREAKER.
□	INDICATES TERMINALS LOCATED IN GENERATOR JUNCTION BOX.
◈	KULKA TB IN MASTER SECTION BY CCI.
⊘	INDICATES TERMINALS LOCATED IN MASTER CONTROL SECTION.
◎	INDICATES TERMINALS LOCATED IN SYNC PANEL.
⊙	INDICATES TERMINALS LOCATED IN GENERATOR CONTROL SECTION.

NOTES:

1. ALL CONTROL WIRING TO BE No. 14 AWG, 600 VOLT, TYPE SIS. EXCEPT AS NOTED. CURRENT TRANSFORMER WIRING TO BE No. 12 AWG.
2. SHIELDED WIRE TO BE No. 18 AWG, 300 VOLT TWISTED LINE WITH 100% FOIL COVERAGE.
3. — — — INDICATES FIELD WIRING BY OTHERS.

REV.	DATE	DESCRIPTION	BY
B	12-02-99	REVISED AS INSTALLED	CMS
A	07-16-99	SHOP AS BUILT	CMS

NSB PURCHASE ORDER No. 19993127-000 OP — CONTROLLED POWER JOB No. 4516

TITLE: GENERATOR DC CONTROL, SCHEMATIC DIAGRAM

CPI DWG No. 8701

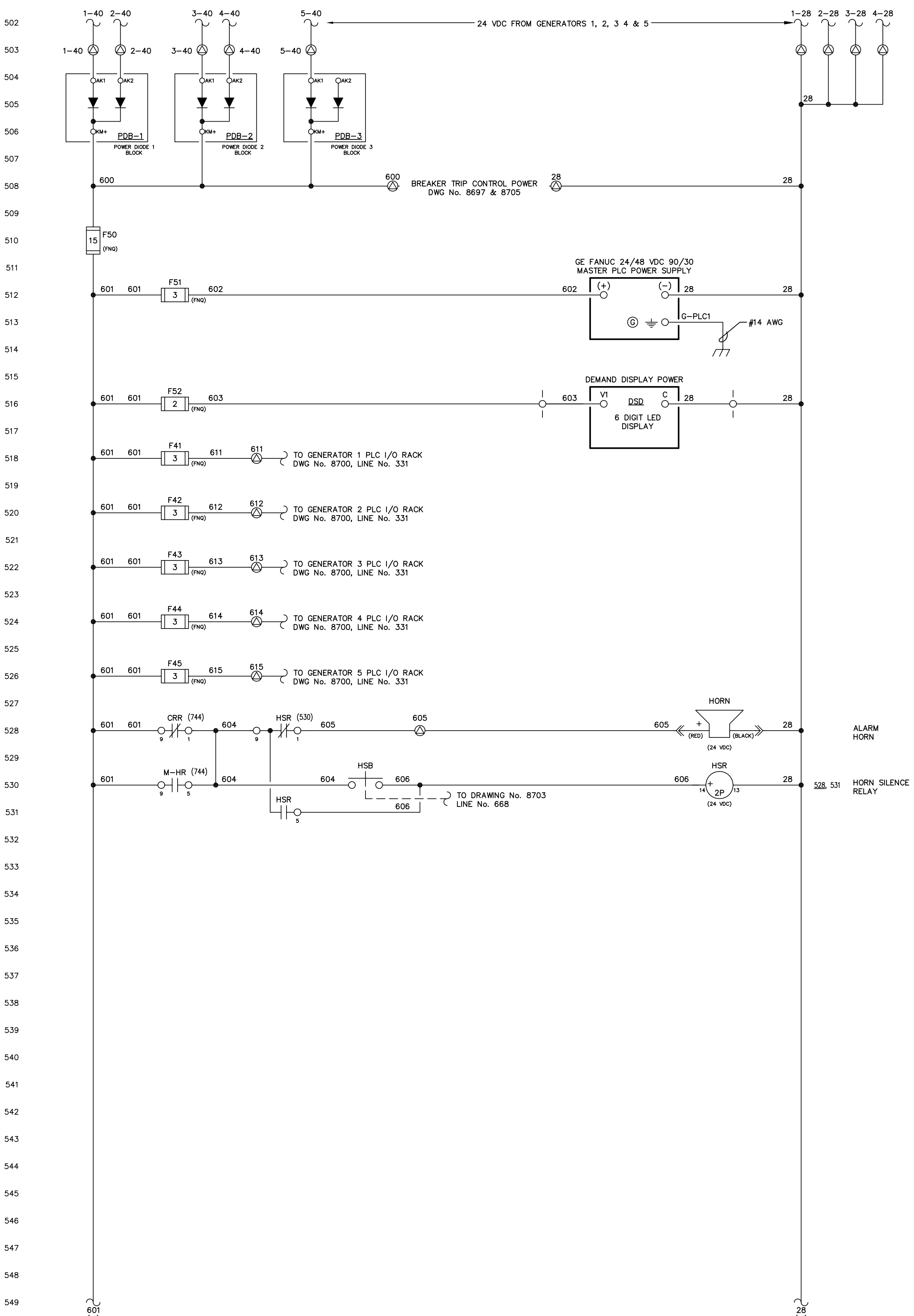
SCALE: NONE | DATE: 04-20-99 | DWN. BY: GPN

DWG. No: 8701 | SHEET: 1 OF 1 | CKD. BY: DLB

JOB: WAINWRIGHT POWER PLANT

NORTH SLOPE BOROUGH
P.O. BOX 69
Barrow, Alaska 99723
(907)852-2611

Plot date: 2013/7/11 – 13:54



LEGEND

SYMBOL	DESCRIPTION
◉	TERMINAL LOCATED AT VILLAGE FEEDER 2 SECTION.
⊠	INDICATES TERMINALS LOCATED ON ATB+.
⊡	INDICATES TERMINALS LOCATED AT ENGINE.
⊗	INDICATES TERMINALS LOCATED AT BREAKER.
□	INDICATES TERMINALS LOCATED IN GENERATOR JUNCTION BOX.
▲	KULKA TB IN MASTER SECTION BY CCI.
△	INDICATES TERMINALS LOCATED IN MASTER CONTROL SECTION.
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2. SHIELDED WIRE TO BE No. 18 AWG, 300 VOLT TWISTED LINE WITH 100% FOIL COVERAGE.
3. — — —INDICATES FIELD WIRING BY OTHERS.

REV.	DATE	DESCRIPTION	BY
B	12-02-99	REVISED AS INSTALLED	CMS
A	07-16-99	SHOP AS BUILT	CMS

NSB PURCHASE ORDER No. 19993127-000 OP — CONTROLLED POWER JOB No. 4516

TITLE: MASTER DC CONTROL, SCHEMATIC DIAGRAM

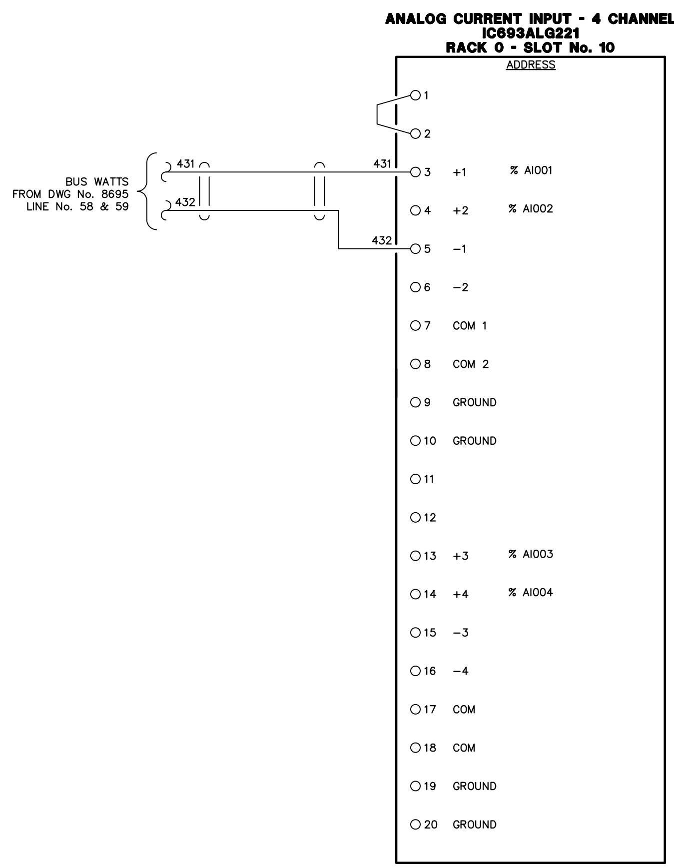
CPI DWG No. 8702

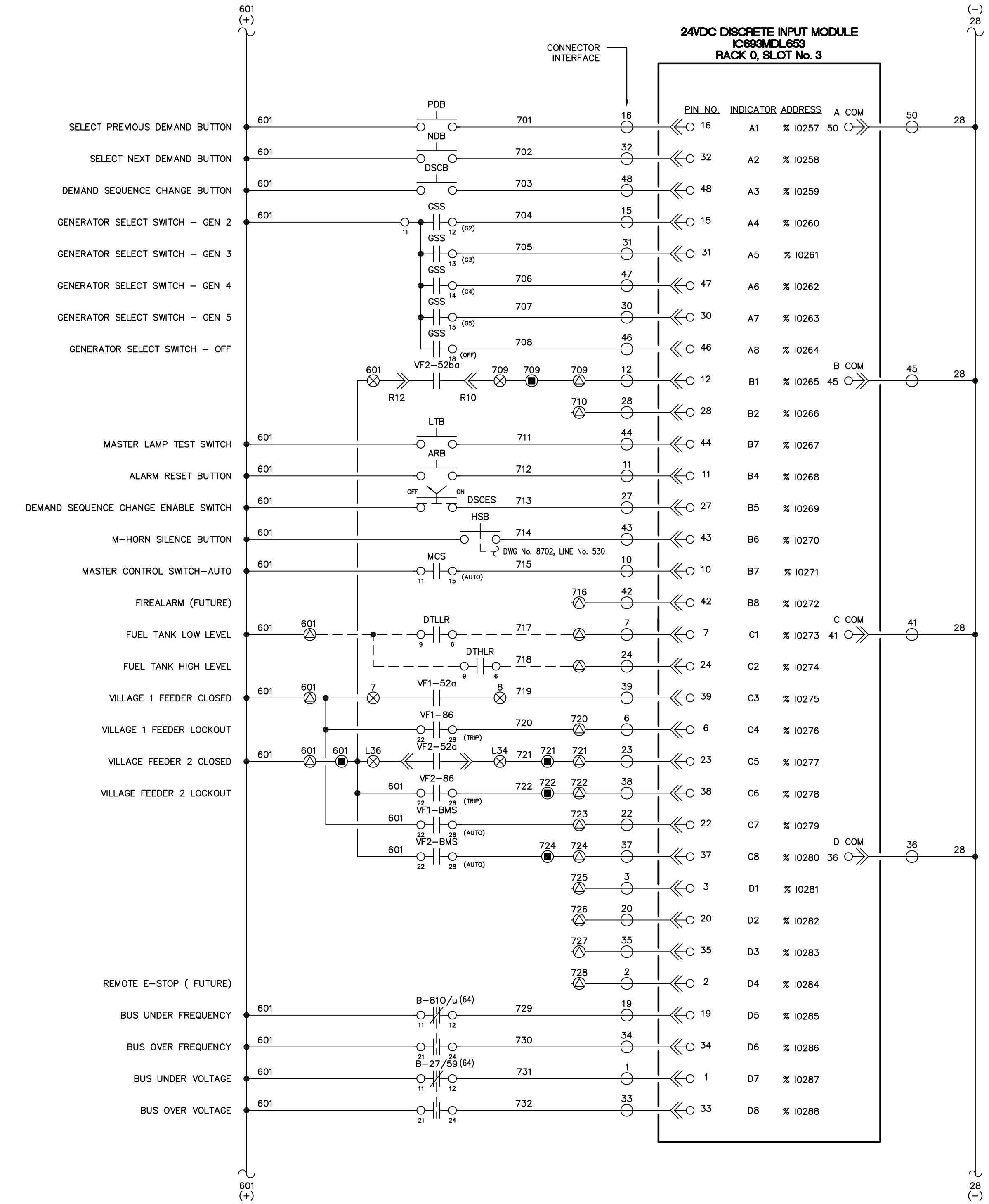
SCALE: NONE	DATE: 06-23-99	DWN. BY: GPN
DWG. No: 8702	SHEET: 1 OF 1	CKD. BY: DLB

JOB: WAINWRIGHT POWER PLANT

NORTH SLOPE BOROUGH
P.O. BOX 69
Barrow, Alaska 99723
(907)852-2611

Plot date: 2013/7/11 – 13:54





LEGEND

SYMBOL	DESCRIPTION
◉	TERMINAL LOCATED AT VILLAGE FEEDER 2 SECTION.
⊠	INDICATES TERMINALS LOCATED ON ATB+.
▣	INDICATES TERMINALS LOCATED AT ENGINE.
⊗	INDICATES TERMINALS LOCATED AT BREAKER.
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NOTES:

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2. SHIELDED WIRE TO BE No. 18 AWG, 300 VOLT TWISTED LINE WITH 100% FOIL COVERAGE.
3. — — —INDICATES FIELD WIRING BY OTHERS.

REV.	DATE	DESCRIPTION	BY
B	12−07−99	REVISED AS INSTALLED	CMS
A	07−16−99	SHOP AS BUILT	CMS

NSB PURCHASE ORDER No. 19993127−000 OP — CONTROLLED POWER JOB No. 4516

TITLE: MASTER DC CONTROL, SCHEMATIC DIAGRAM

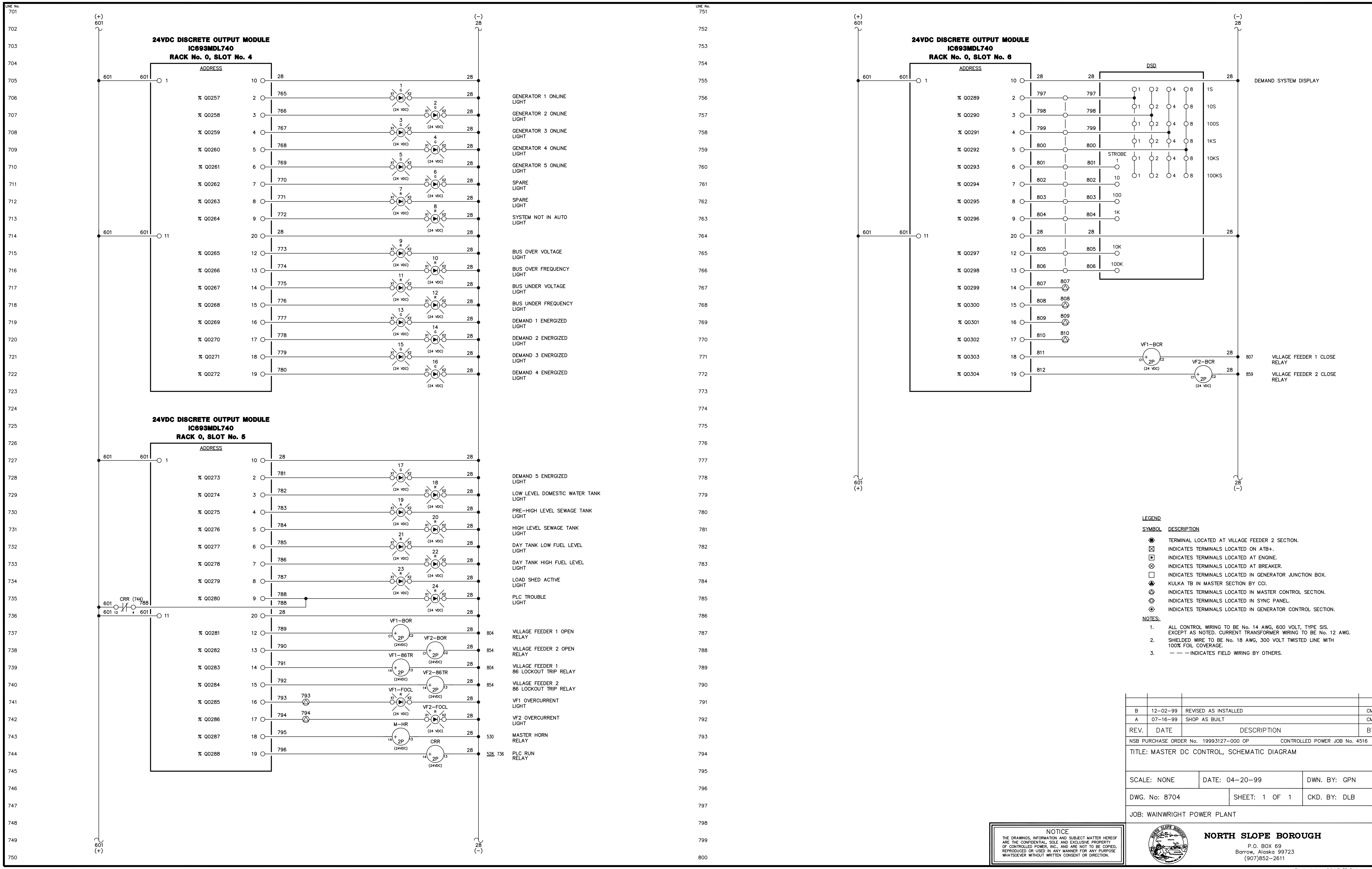
CPI DWG No. 8703

SCALE: NONE	DATE: 06−23−99	DWN. BY: GPN
DWG. No: 8703	SHEET: 1 OF 1	CKD. BY: DLB

JOB: WAINWRIGHT POWER PLANT

NORTH SLOPE BOROUGH
P.O. BOX 69
Barrow, Alaska 99723
(907)852−2611

Plot date: 2013/7/11 − 13:54



LEGEND

SYMBOL	DESCRIPTION
	TERMINAL LOCATED AT VILLAGE FEEDER 2 SECTION.
	INDICATES TERMINALS LOCATED ON ATB+.
	INDICATES TERMINALS LOCATED AT ENGINE.
	INDICATES TERMINALS LOCATED AT BREAKER.
	INDICATES TERMINALS LOCATED IN GENERATOR JUNCTION BOX.
	KULKA TB IN MASTER SECTION BY CCI.
	INDICATES TERMINALS LOCATED IN MASTER CONTROL SECTION.
	INDICATES TERMINALS LOCATED IN SYNC PANEL.
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3. — — — INDICATES FIELD WIRING BY OTHERS.

REV.	DATE	DESCRIPTION	BY
B	12-02-99	REVISED AS INSTALLED	CMS
A	07-16-99	SHOP AS BUILT	CMS

NSB PURCHASE ORDER No. 19993127-000 OP — CONTROLLED POWER JOB No. 4516

TITLE: MASTER DC CONTROL, SCHEMATIC DIAGRAM

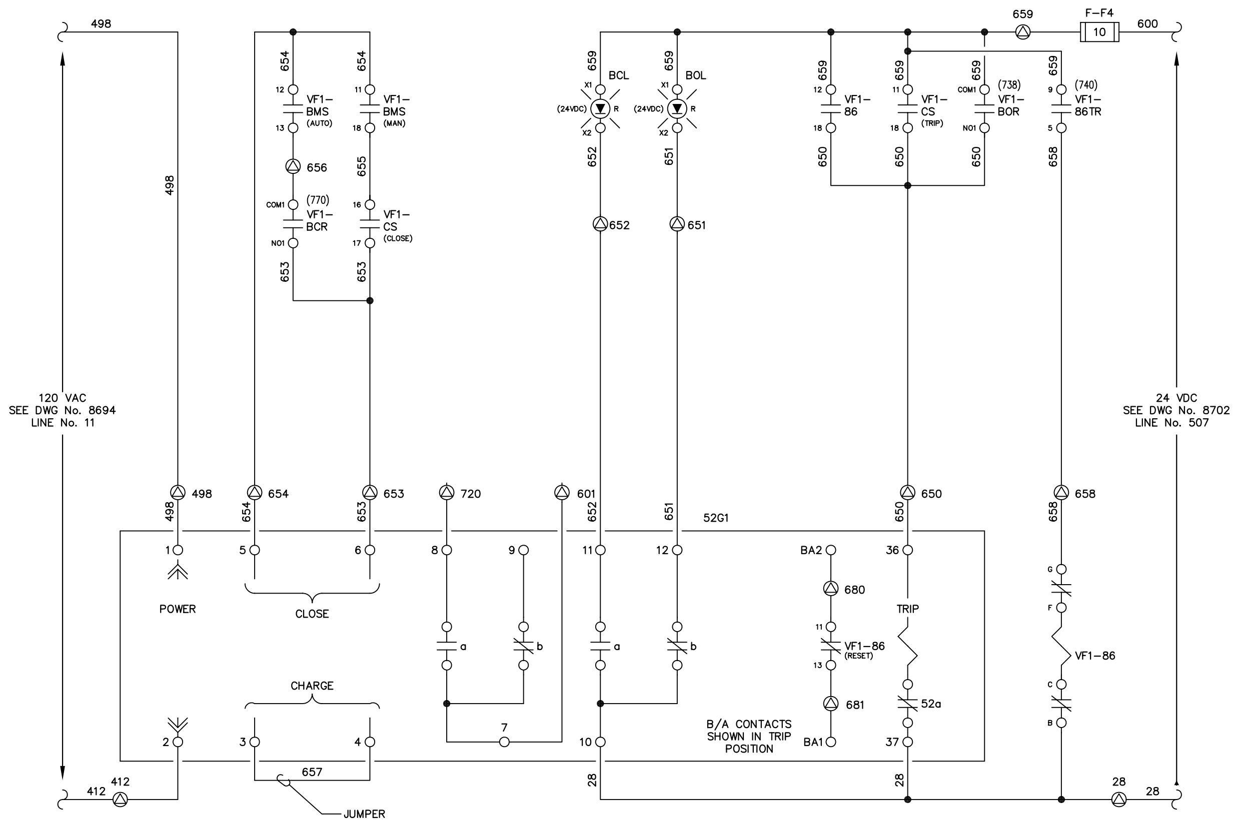
SCALE: NONE — DATE: 04-20-99 — DWN. BY: GPN

DWG. No: 8704 — SHEET: 1 OF 1 — CKD. BY: DLB

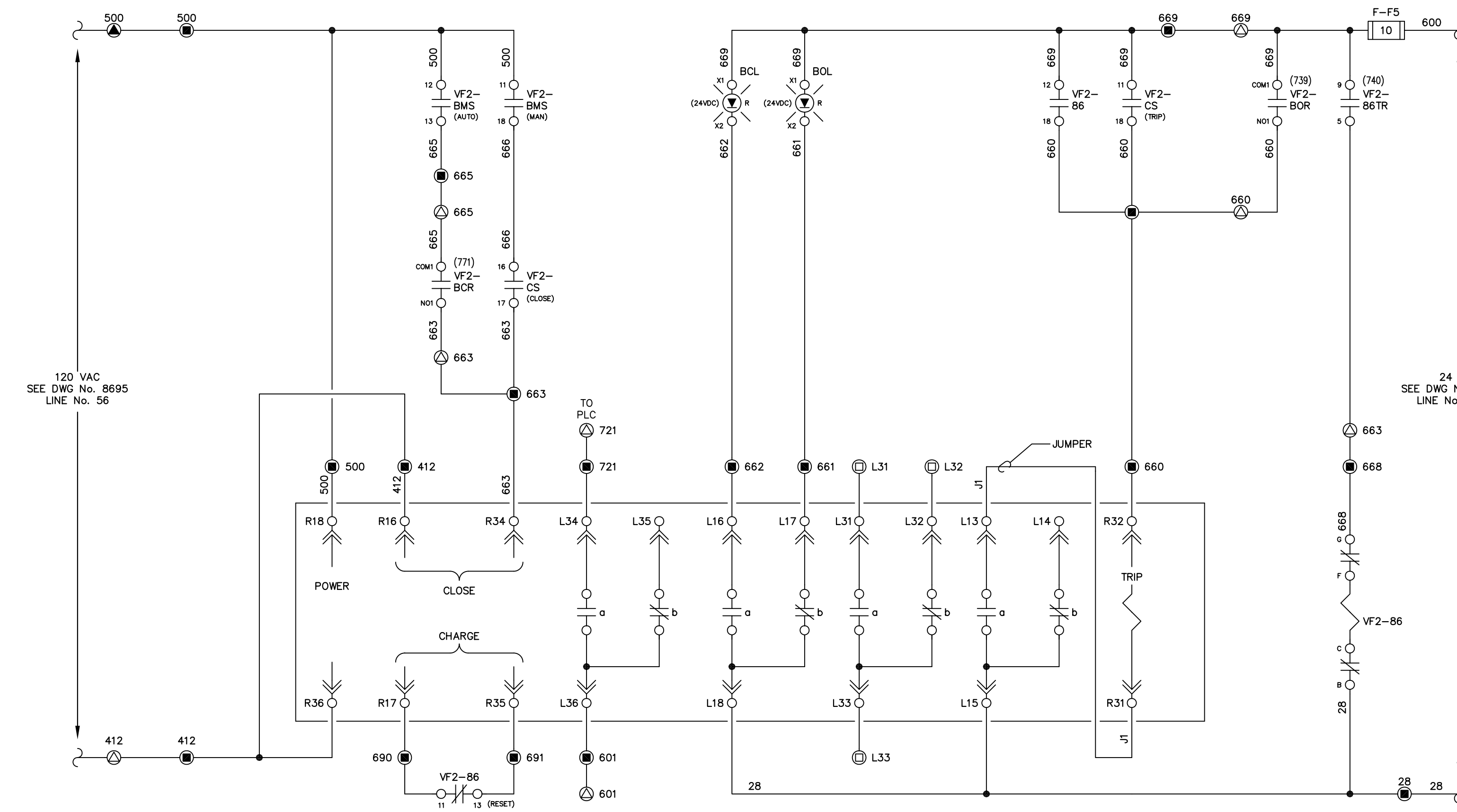
JOB: WAINWRIGHT POWER PLANT

NORTH SLOPE BOROUGH
P.O. BOX 69
Barrow, Alaska 99723
(907)852-2611

Plot date: 2013/7/11 – 13:53



WEST VILLAGE FEEDER 1 BREAKER (VF1-52)
POWER BREAK I



EAST VILLAGE FEEDER 2 BREAKER (VF2-52)
POWER BREAK II

LEGEND

SYMBOL — DESCRIPTION

- TERMINAL LOCATED AT VILLAGE FEEDER 2 SECTION.
- INDICATES TERMINALS LOCATED ON ATB+.
- INDICATES TERMINALS LOCATED AT ENGINE.
- INDICATES TERMINALS LOCATED AT BREAKER.
- INDICATES TERMINALS LOCATED IN GENERATOR JUNCTION BOX.
- KULKA TB IN MASTER SECTION BY CCI.
- INDICATES TERMINALS LOCATED IN MASTER CONTROL SECTION.
- INDICATES TERMINALS LOCATED IN SYNC PANEL.
- INDICATES TERMINALS LOCATED IN GENERATOR CONTROL SECTION.

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2. SHIELDED WIRE TO BE No. 18 AWG, 300 VOLT TWISTED LINE WITH 100% FOIL COVERAGE.
3. — — —INDICATES FIELD WIRING BY OTHERS.

REV.	DATE	DESCRIPTION	BY
B	12-06-99	REVISED AS INSTALLED	CMS
A	07-16-99	SHOP AS BUILT	CMS

NSB PURCHASE ORDER No. 19993127-000 OP — CONTROLLED POWER JOB No. 4516

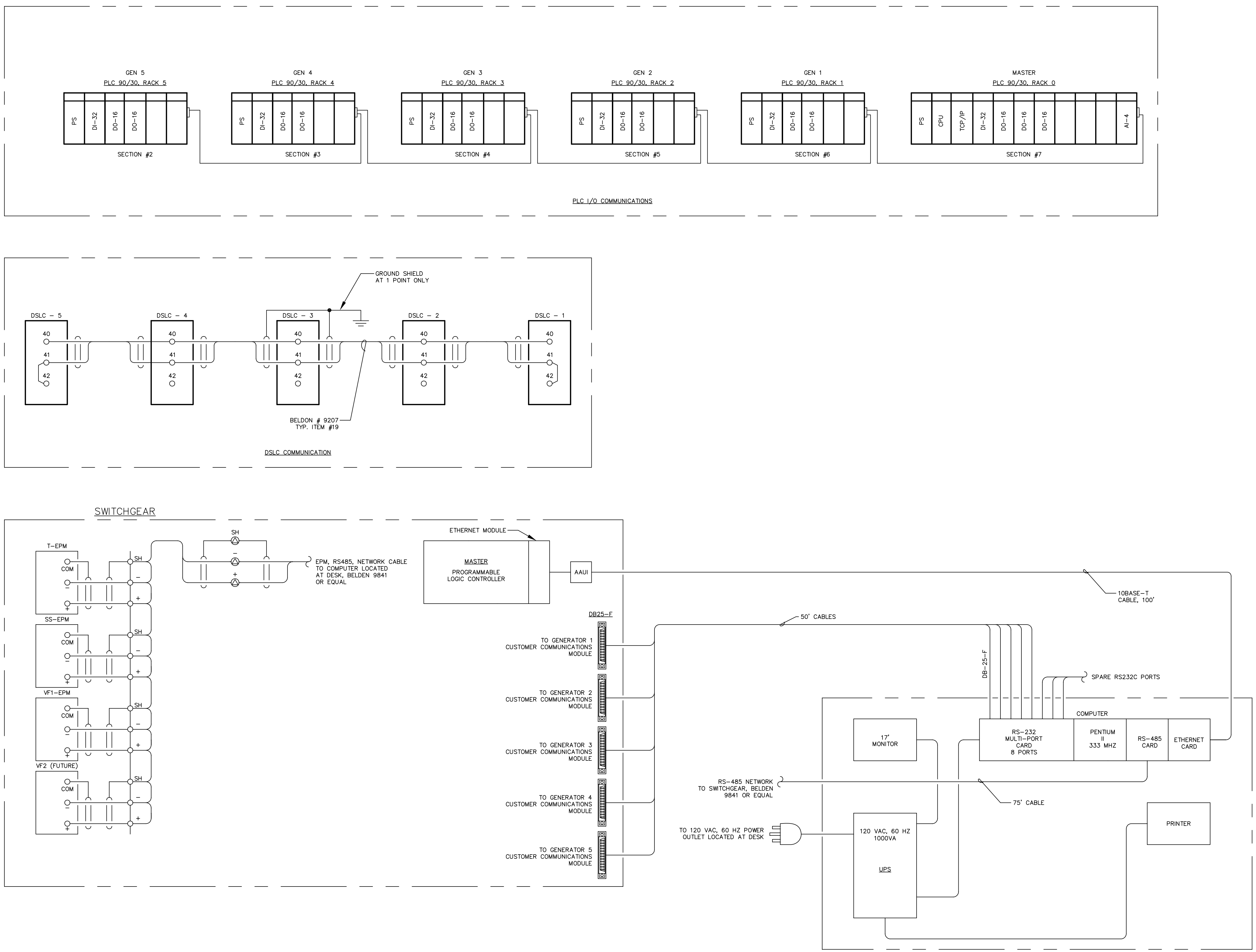
TITLE: FEEDER BREAKER CONTROL, SCHEMATIC DIAGRAM

SCALE: NONE	DATE: 06-23-99	DWN. BY: GPN
DWG. No: 8705	SHEET: 1 OF 1	CKD. BY: DLB

JOB: WAINWRIGHT POWER PLANT

NORTH SLOPE BOROUGH
P.O. BOX 69
Barrow, Alaska 99723
(907)852-2611

Plot date: 2013/7/11 – 13:53



REV.	DATE	DESCRIPTION	BY
A	07-16-99	SHOP AS BUILT	CMS

NSB PURCHASE ORDER No. 19993127-000 OP   CONTROLLED POWER JOB No. 4516

TITLE: COMMUNICATIONS SINGLE LINE

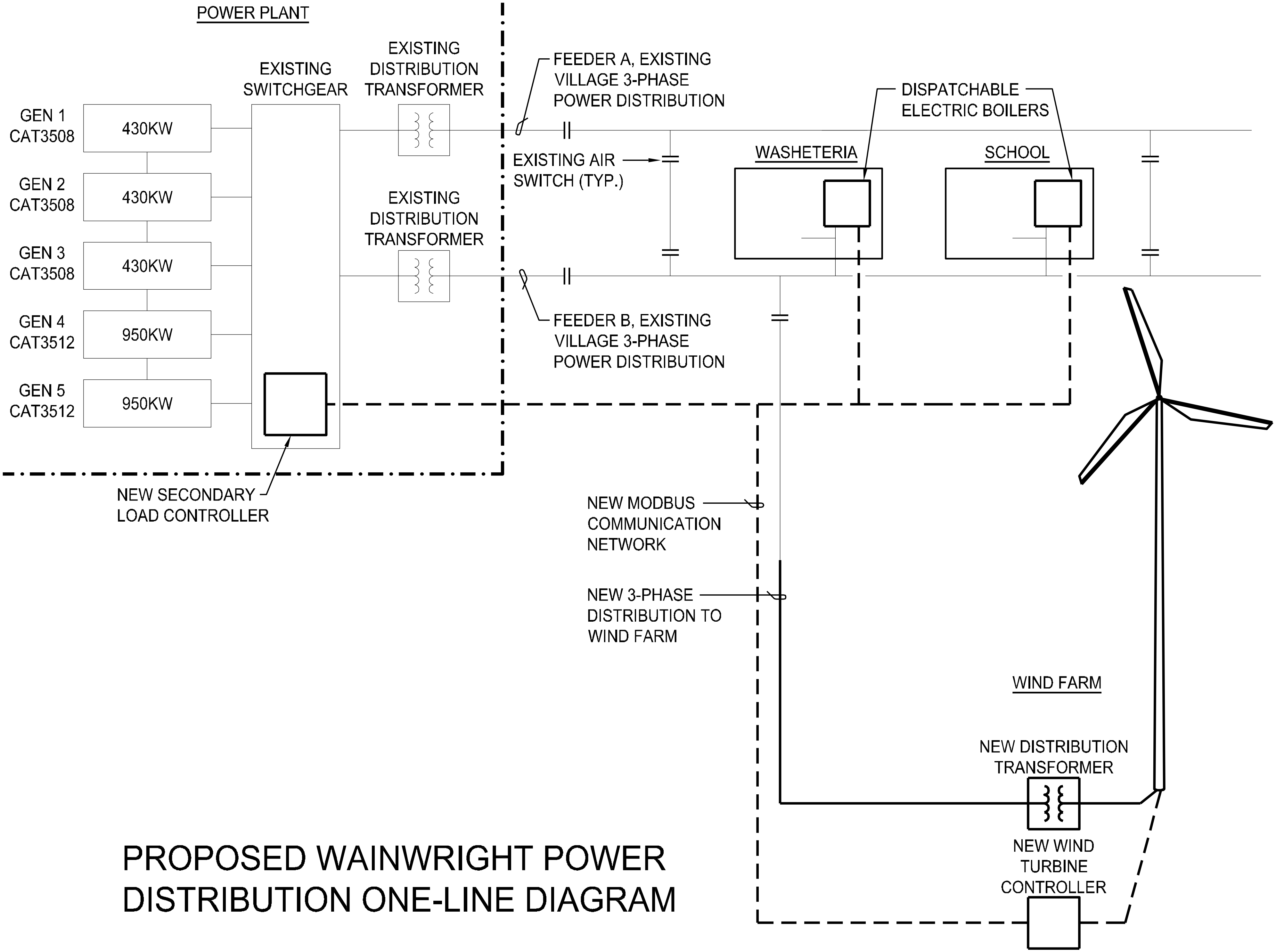
CPI DWG No. 8706

SCALE: NONE	DATE: 04-20-99	DWN. BY: GPN
DWG. No: 8706	SHEET: 1 OF 1	CKD. BY: DLB

JOB: WAINWRIGHT POWER PLANT

NORTH SLOPE BOROUGH
P.O. BOX 69
Barrow, Alaska 99723
(907)852-2611

Appendix D – Proposed System One-Line Diagram



PROPOSED WAINWRIGHT POWER DISTRIBUTION ONE-LINE DIAGRAM

Appendix E – Power Distribution System Expansion for Sites A and B

LEGEND	
red line	PHASE A
green line	PHASE B
blue line	PHASE C

300' 150' 0 300'

APPROXIMATE SCALE: 1"=300'

WHPacific
300 West 31st Avenue
Anchorage, AK 99503
907-339-6500 Fax 907-339-5327
www.whpacific.com

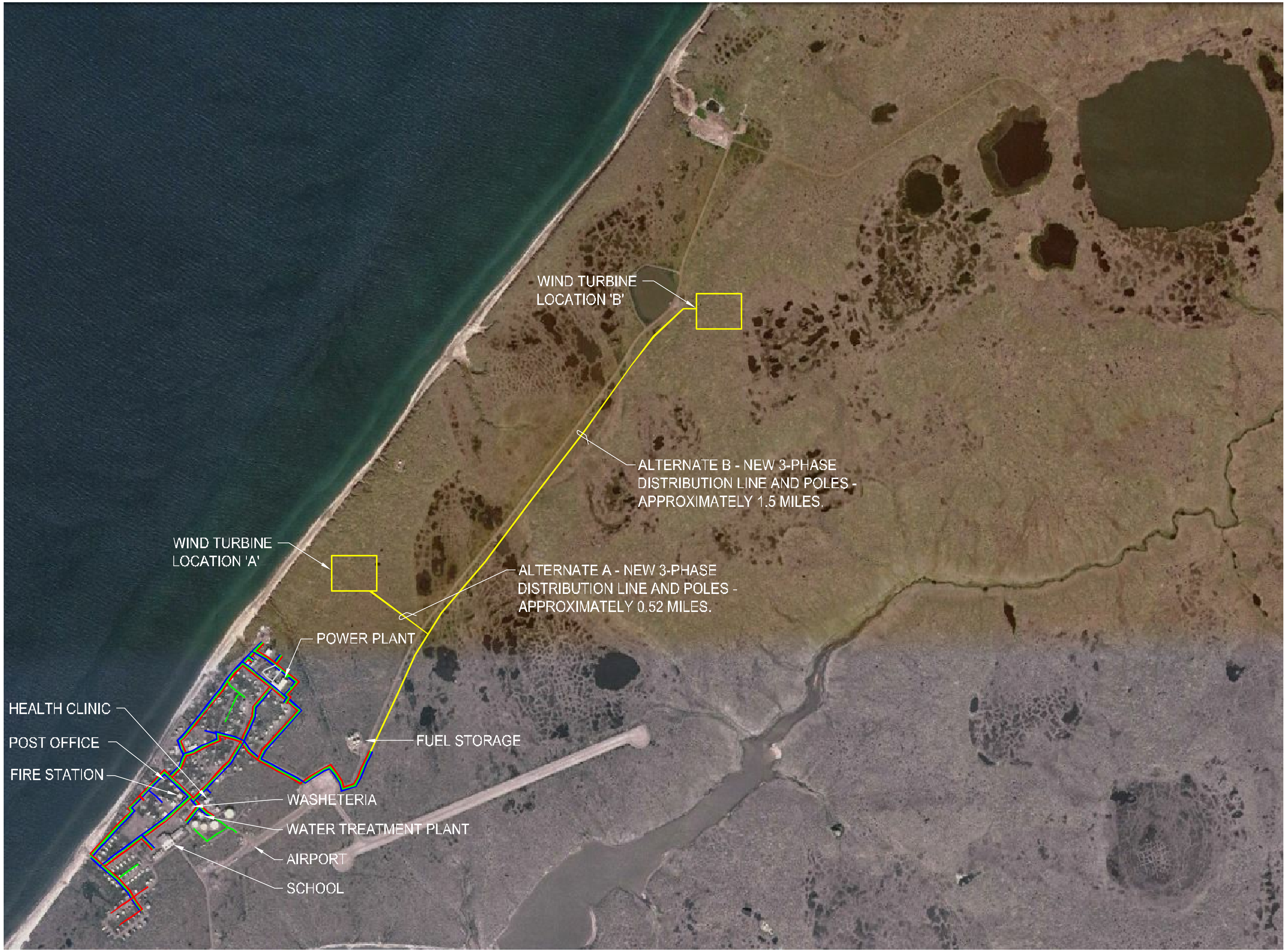
WAINWRIGHT

SHEET 1 of 2

DATE: 01/05/2014

SHEET NO.:

E1



LEGEND
PHASE A
PHASE B
PHASE C
NEW 3-PHASE
UPGRADE TO 3-PHASE

SCALE: NONE

WHPacific
300 West 31st Avenue
Anchorage, AK 99503
907-339-6500 Fax 907-339-5327
www.whpacific.com

WAINWRIGHT

SHEET 2 of 2
DATE: 01/05/2014
SHEET NO.:
E2