

APPENDIX A AESO CONNECTION ASSESSMENT

Engineering Study Report

AESO Project: RP-864

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Dec 05, 10



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APEGGA Permit to Practice P-08200

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KXL Pipeline pump Station Load Connection

1.0 BACKGROUND

Trans Canada Corporation is proposing an expansion to extend the existing Keystone Pipeline Project currently under construction. The KXL Pipeline expansion will require additional Hardisty terminal pumping and storage facilities and four (4) transfer pumping stations along the Alberta pipeline section.

Table 1-1 below generally summarizes the approximate locations of the respective KXL pumping stations.

Table 1-1: Location of Keystone KXL Pipeline Pumping Stations

Station	Name	Location (LSD-SEC-TWP-RGE)*
PS 2	Lakesend East	3 – 14 – 39 – 6
PS 3	Monitor South	7 - 25 - 33 - 5
PS 4	Oyen South	16 – 20 – 27 - 4
PS 5	Bindloss South	16 – 20 – 21 - 2

*All land locations are West of the 4th Meridian.

Table 1-2 below generally summarizes the service details for the respective KXL pumping stations.

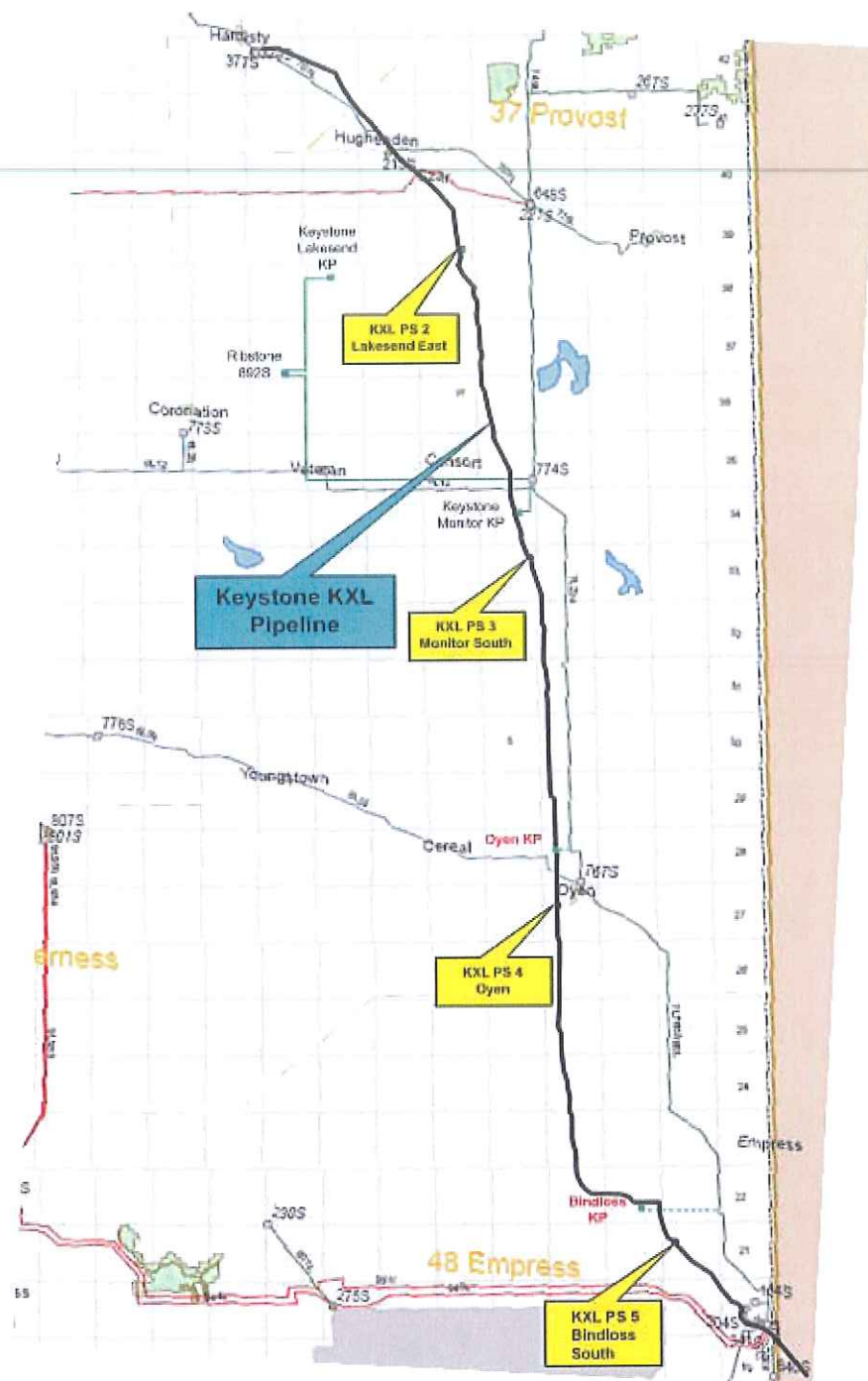
Station	Name	Load Development (MW)					
		Stage 1	In-Service Date	Stage 2	In-Service Date	Stage 3	In-Service Date
PS 2	Lakesend East	1	2012-03-31	12	2012-11-01	15	Note 1.
PS 3	Monitor South	1	2012-04-28	12	2012-11-01	15	Note 1.
PS 4	Oyen South	1	2012-05-26	12	2012-11-01	15	Note 1.
PS 5	Bindloss South	1	2012-03-18	12	2012-11-01	15	Note 1.

NOTES:

1. All pump stations have an ultimate load projection of 25 MW, presently estimated to occur approximately 5 years after Stage 2 completion.

Figure 1-1 shows the proposed KXL pipeline routing and Alberta pumping station locations relative to existing area transmission system facilities.

Figure 1-1: Keystone Pipeline Alberta KXL Pump Station Locations



The addition of the Keystone and Keystone KXL Pipeline pump stations combined with other area load and wind generation growth were included in the southeastern Alberta regional transmission assessment comprising the Hanna (Area 42), Wainwright (Area 32), Alliance/Battle River (Area 36), Provost (Area 37) and Sheerness (Area 43) planning areas. The AESO subsequently applied and received

approval for the Hanna Region Transmission Development to address identified deficiencies (http://www.aeso.ca/downloads/Hanna_NID_Filing_Aug14_Final.pdf).

ATCO Electric advised that service to the Oyen South and other KXL pumping stations in its service territory cannot be accomplished utilizing area 25 kV distribution infrastructure (ATCO Electric TransCanada KXL pipeline project, Appendix A). A transmission supply proposal was requested for the Monitor South pumping station. Discussions regarding supply security indicated that single-line extensions of, or taps from, existing area transmission circuits with single-transformer substations would be acceptable for all of the pipeline pumping stations provided the resulting configuration would not result in the simultaneous loss of sequential transfer pumping stations.

While a number of service connection alternatives are possible for connecting the Oyen South (Armitage 949S) pump station to the system, only one was given serious consideration based on 144 kV supply option. All others were eliminated based on engineering judgment and cost considerations.

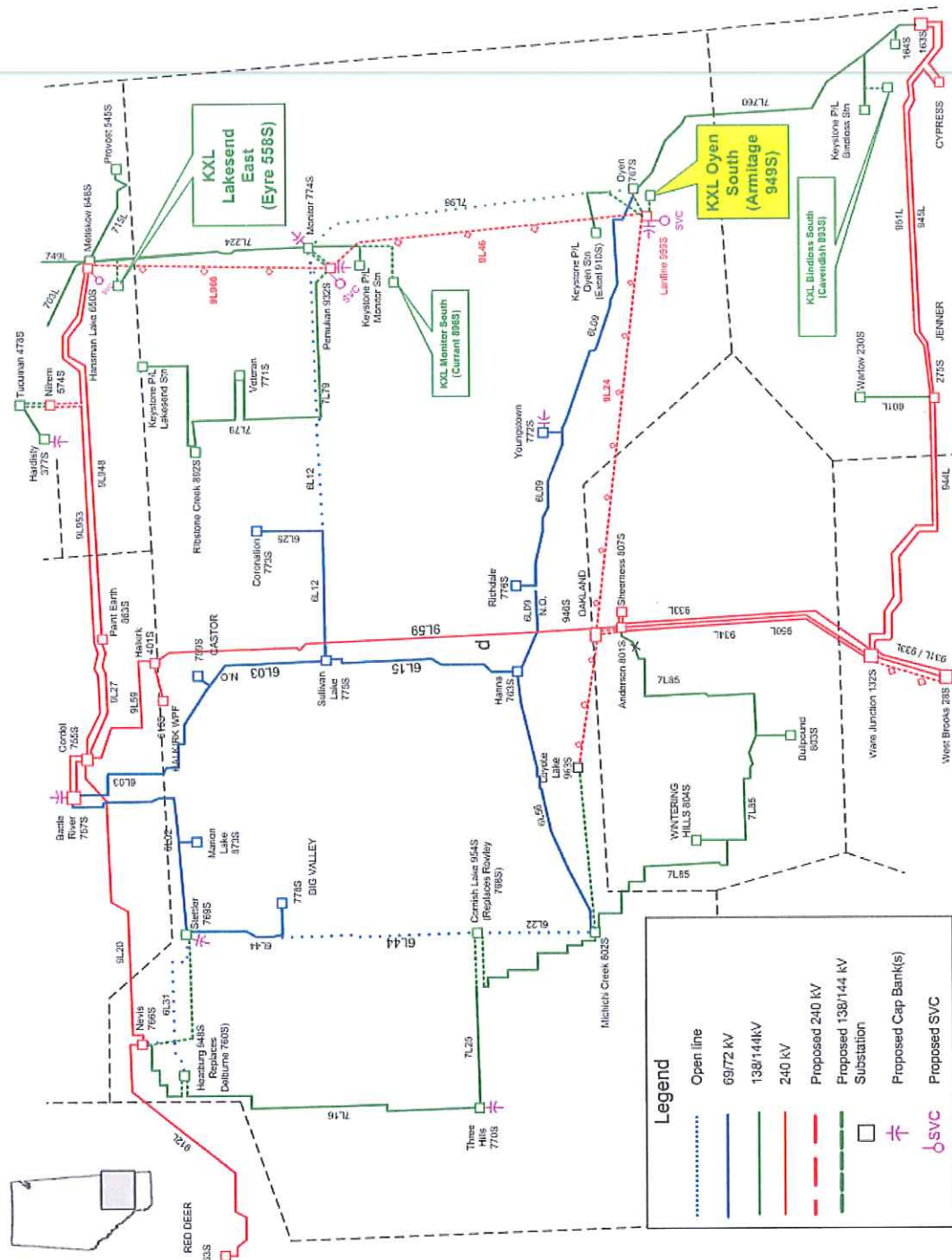
Proposed Alternative 1 involved constructing approximately 12 km long new single-circuit transmission line from Lanfine 959S to a 20/26.6/33.3 MVA 144-6.9 kV Armitage 949S at the Oyen South pump station.

ATCO Electric elected to proceed with Alternative 1, the construction of approximately 12 km long new single-circuit 144 kv transmission line from Lanfine 959S to a 20/26.6/33.3 MVA 144-6.9 kV Armitage 949S at the Oyen South pump station.

Figure 1-2 is a regional transmission system one-line diagram showing the initial stage of Hanna Regional Transmission Development highlighting the proposed KXL pipeline Oyen South (Armitage 949S) pump station service connection. Future Keystone KXL pipeline pump station locations are also indicated for information purposes.

Attachment A contains more detailed single-line diagram representations of the proposed KXL Oyen South (Armitage 949S) pump station service connection development. The connecting transmission line will be constructed with 266.8 Kcmil ACSR conductors to match existing circuit 7L110. The remaining KXL pipeline pump station service connections are indicated for information purposes only. Separate connection applications will be forwarded for the remaining pump stations in due course.

Figure 1-2: Keystone KXL Oyen South (Armitage 949S) Pipeline Pump Station Connection



2.0 Criteria and Assumptions

The impact of the KXL pipeline Oyen South (Armitage 949S) and remaining KXL pipeline pump station connections has already been addressed from a regional perspective in the Hanna Region Transmission Development. This engineering report only deals with the specific alterations and augmentation of the local transmission network to accommodate ATCO Electric's preferred connection for the KXL pipeline Oyen South (Armitage 949S) pump station in the context of the greater Hanna Region Transmission Development.

2.1 Load Forecast

All Keystone KXL pipeline pump station service load was included in the forecasted load development used for AESO Hanna Region Transmission study and reinforcement development including the KXL pipeline Oyen South (Armitage 949S) connection.

2.2 Generation Assumptions

No generation addition is proposed or included in the KXL pipeline Oyen South or other pump station connections. Generation assumptions appearing in the AESO Hanna Region Transmission study and reinforcement development NID were used to assess the 2012 KXL pipeline Oyen South pump station connection impacts.

2.3 Facility Ratings

Transmission facility ratings were reviewed and proposed upgrading, augmentation or mitigative measures have been addressed in the AESO's Hanna Region Transmission Development. Table 2.3-1 summarizes capability of new transmission line construction and circuit 7LA760 comprising the KXL pipeline Oyen South pump station service connection.

Table 2.3-1
Transmission Connection Ratings (MVA)

Element	From	To	Conductor	Summer	Winter
7Lxxx	Lanfine 959S	Armitage 949S	266.8 ACSR	120	146
Armitage 949S	144 kV bus	6.9 kV bus	N/A	20/26.6/33.3	

2.4 Reliability Criteria

AESO Transmission Reliability Criteria was applied in the AESO Hanna Region Transmission study to test the performance of the area transmission system under Category A (i.e. all elements in service) and Category B (i.e. one element out-of-service) events with due regard to radially connected loads. Category B contingencies also cover single element outage events while the most critical generator is out of service for maintenance or for commercial reasons, and the remaining generators in the system are dispatched according to the forecast merit order. AESO Reliability Criteria requires that the system remain stable, all

equipment operate within applicable thermal and voltage limits and that all applicable performance standards are respected.

3.0 Impact Assessment

All anticipated Keystone and Keystone KXL pipeline loads were included in the load forecast utilized in the Hanna Region Transmission Development Study(HRTD)¹. This study region comprised of Hanna-Area 42, Wainwright-Area 32, Alliance/Battle River-Area 36, Provost-Area 37 and Sheerness-Area 43 planning areas. The HRTD steady-state and transient impact assessments included all Keystone and Keystone KXL pipeline pump station loads. Studies performed on the Stage 1 development proposed for completion in 2012 included the ultimate load forecast for the Keystone KXL pipeline pump stations thereby ensuring that the proposed reinforcement would be sufficient to satisfy this requirement until the second stage of development is completed (2017 presently proposed). In the HRTD study, the KXL pump station loads were connected to local 138/144 kV substation buses for steady-state and transient study purposes. Attachment B contains copies of power flows for Alternatives 1 & 3 Hanna Region Transmission Development for normal 2012 summer light, summer peak and winter peak cases studied showing the locations of the respective KXL pump station load connections used in the studies.

Hanna Region Transmission reinforcement developments are presently anticipated to be in place by August of 2012. TransCanada Corporation requested that connection facilities required to accommodate full operation at the respective pumping station locations be available to provide approximately 1 MW of construction power by the second quarter of 2012 (Table 1.0-1) in advance of some of the proposed 2012 Hanna Region Transmission reinforcement developments. None of the pumps will be operated prior to completion of associated critical elements of the Hanna Region Transmission reinforcement developments.

4.0 Available Short Circuit Currents

Short circuit current levels for the Armitage 949S substation (KXL pipeline Oyen South pump station service) are provided below². The values were generated using topology and generation dispatch representations utilized for 2012 Hanna region transmission reinforcement Stage1 development system impact assessment studies. Other area substation levels can be obtained from the Hanna Region Transmission Development NID.

¹ The AESO filed the Hanna Region Transmission Development NID with AUC and received its approval(Proceeding ID .278 and Application No.1605359)

² Short circuit current calculation is based on modeling information provided to the AESO by third parties. Short circuit estimation is subject to change. The information provided in this study is not intended to be used as the sole source of information for electrical equipment specification and the design of public or worker safety-grounding systems.

Table 4-1
Estimated Armitage 949S 2017 Available Short Circuit Current Levels

Name	Voltage (pu)	3-Phase Fault Current(A)	Pos. Seq. Imp. (pu)	1-Phase Fault Current (A)	Zero. Seq. Imp. (pu)
Armitage 949S	1.06	4,151	0.04201 + j0.09846	2,612	0.07953 + j0.2862

NOTES:

1. P.U. pre-fault voltage; $V_{base} = V_{bus}$
2. P.U. quantity, $MVA_{base} = 100$.
3. The AESO is currently in the process of verifying and validating the sequence impedance data for the AIES. The Line to Ground (L-G) 1-phase fault levels therefore has a tolerance of +/- 10%.

5.0 Summary and Conclusions

AESO's studies for the existing system considering the addition of the Keystone and Keystone KXL Pipeline Projects combined with other area load and wind generation growth for the Hanna (Area 42), Wainwright (Area 32), Alliance/Battle River (Area 36), Provost (Area 37) and Sheerness (Area 43) planning areas indicated thermal, voltage and stability deficiencies. The existing system topology was incapable of accommodating most of the anticipated load growth in the area including the Keystone KXL pipeline pump station service requirements. The AESO investigated a number of reinforcement alternatives and subsequently applied for and received approval to proceed with Hanna Region Transmission (Reinforcement) Development. The proposed Hanna Region Transmission development addresses all forecasted load and wind generation development including the proposed Keystone KXL pipeline pump station service requirements.

Table 1-2 provides staged load developments for the Keystone KXL pipeline Oyen South pump station service. The Hanna region transmission reinforcement Stage1 development (2012) included Keystone KXL pipeline Oyen South pump station service stage 3 load development (2015) to ensure capability to serve Keystone KXL pipeline pump station services until Hanna region transmission reinforcement Stage2 development is completed (2017).

The existing Hanna region transmission is capable of providing the approximate 1 MW construction power requirement for the Oyen South and all remaining Keystone KXL pump station services in advance of the Hanna Region Transmission Stage 1 Development completion.

ATTACHMENT A

Single Line Diagrams

**KXL Pipeline Oyen South Pump Station (Armitage
949S) Service Connection**

Figure A-1: KXL Pipeline Oyen South Pump Station (Armitage 949S) Service Connection Development

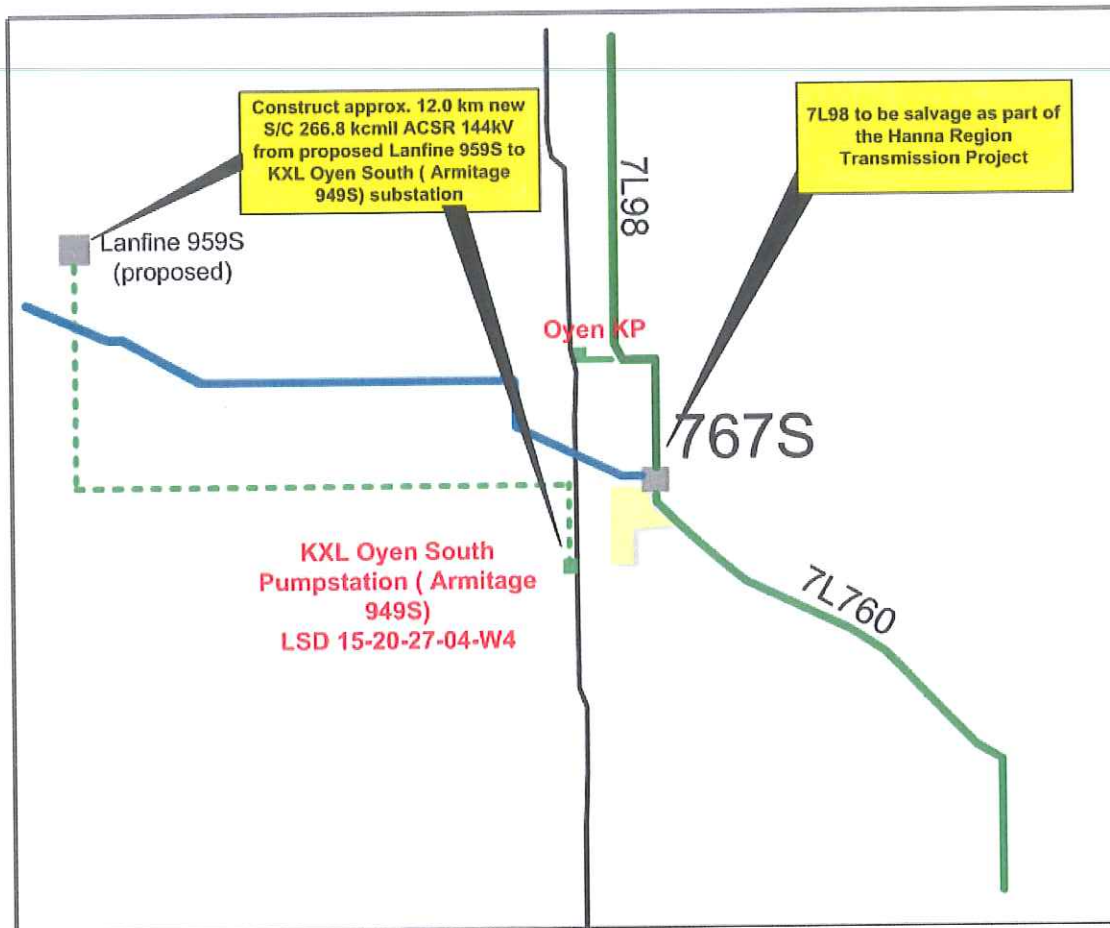
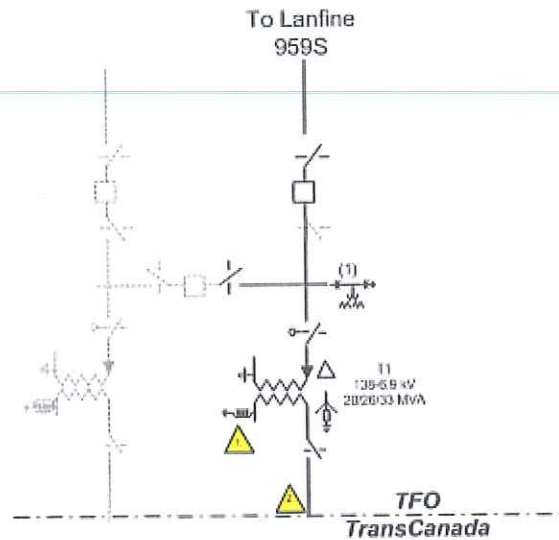


Figure A-2: KXL Pipeline Oyen South Station Service (Armitage 949S) Connection Development



NOTES

- ▲ Grounding resistor/reactor to be specified and procured by Customer, installed by AML.
- ▲ Facility to accommodate O/H cable terminations; rack-out switchgear & 13.8 kV insulation/stds assumed for substation infrastructure.

LEGEND

- Proposed —————
- Future (Layout Planning Only) - - - - -
- Power Circuit Breaker (Outdoor, open-air)
 - ⎓ Gang-operated air-switch; motor-operated
 - ⎓ Gang-operated air-switch; manual-operated
 - ⎓ Hookstick operated disconnect switch; one per electrical phase
 - ⎓ Potential (voltage) transformer(s); (3) = 3 phases
 - 25 kV underground cable to DFO riser pole or switching facilities beyond station fence.
 - Δ Two-winding power transformer; delta HV-wye LV connected; LV resistance or reactance grounded.

ATTACHMENT B

2012 Hanna Region Transmission Development Study Power Flow Diagrams

KXL Pipeline Pump Station Load Connection

Figure B-1
KXL Pump Station Load Modeled
Alt 1&3 WP BR5 Off No Additional Wind
Hanna Region Transmission Development

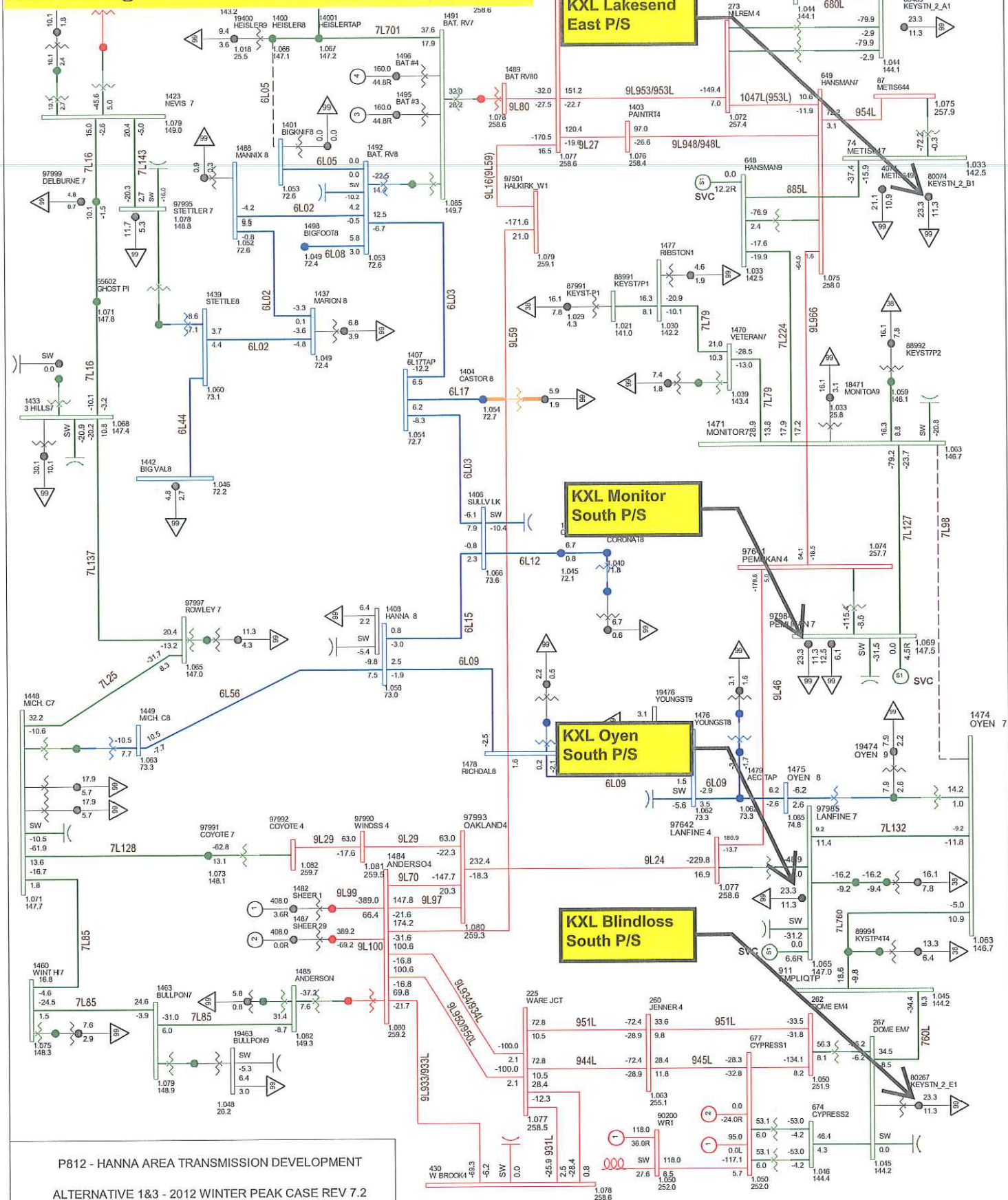
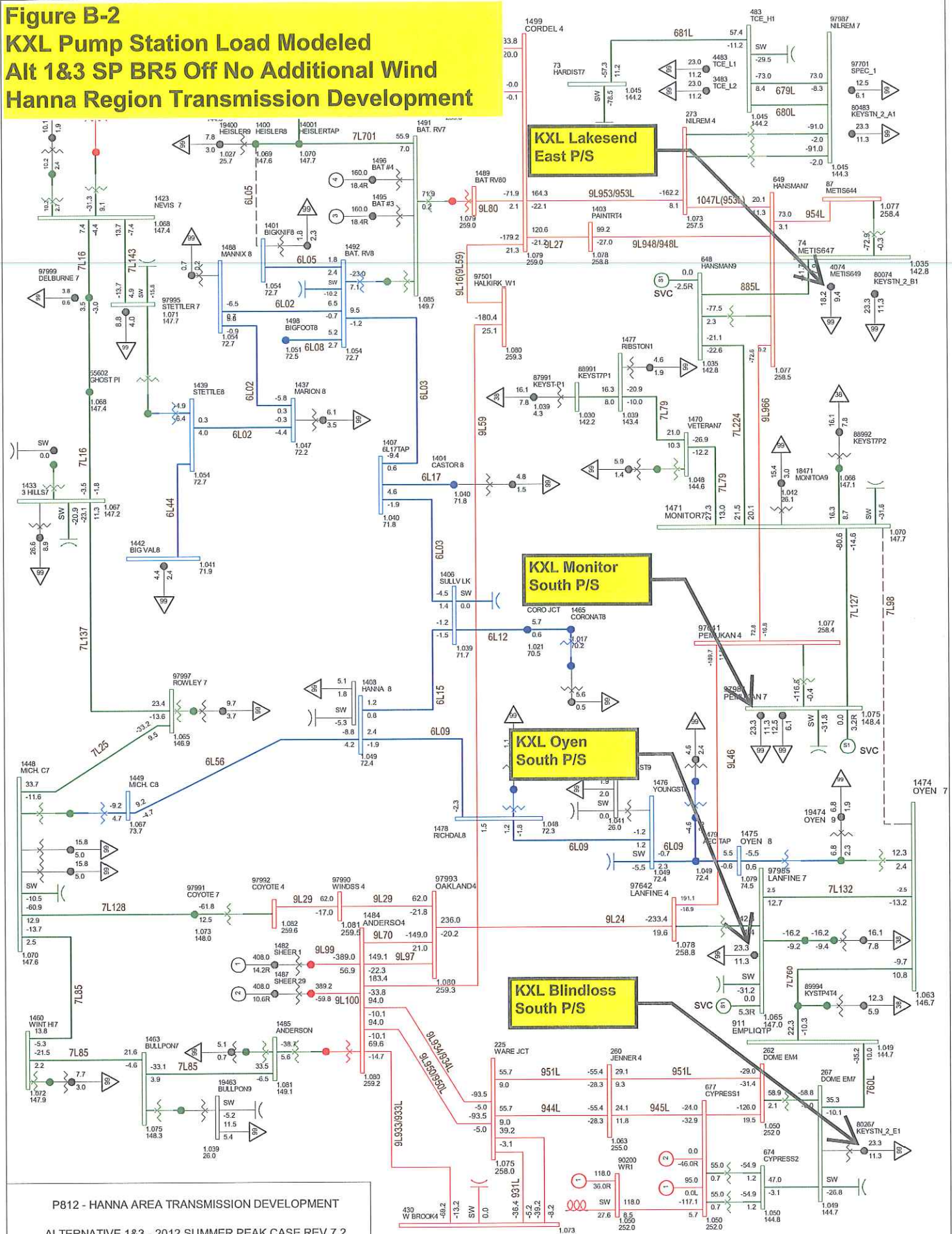


FIG 2012-ALTERNATIVE 1&3-SP-20 (BR UNIT 5 OFF)
ALL ELEMENTS IN SERVICE
SUN, JUL 26 2009 13:46

D-2012-22

Figure B-2
KXL Pump Station Load Modeled
Alt 1&3 SP BR5 Off No Additional Wind
Hanna Region Transmission Development



P812 - HANNA AREA TRANSMISSION DEVELOPMENT

ALTERNATIVE 1&3 - 2012 SUMMER PEAK CASE REV 7.2

Bus - VOLTAGE (KV/PU)
 Branch - MW/MVAR
 Equipment - MW/MVAR
 1000/0.1/0.1/0.1
 KW: <34.500 <72.000 <144.000 <288.000 <576.000 <1152.000

FIG 1012-ALT1&3-SP-1 (BR UNIT 5 OFF)
 ALL ELEMENTS IN SERVICE
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D-2012-44

Figure B-3
KXL Pump Station Load Modeled
Alt 1&3 SL BR5 Off No Additional Wind
Hanna Region Transmission Development

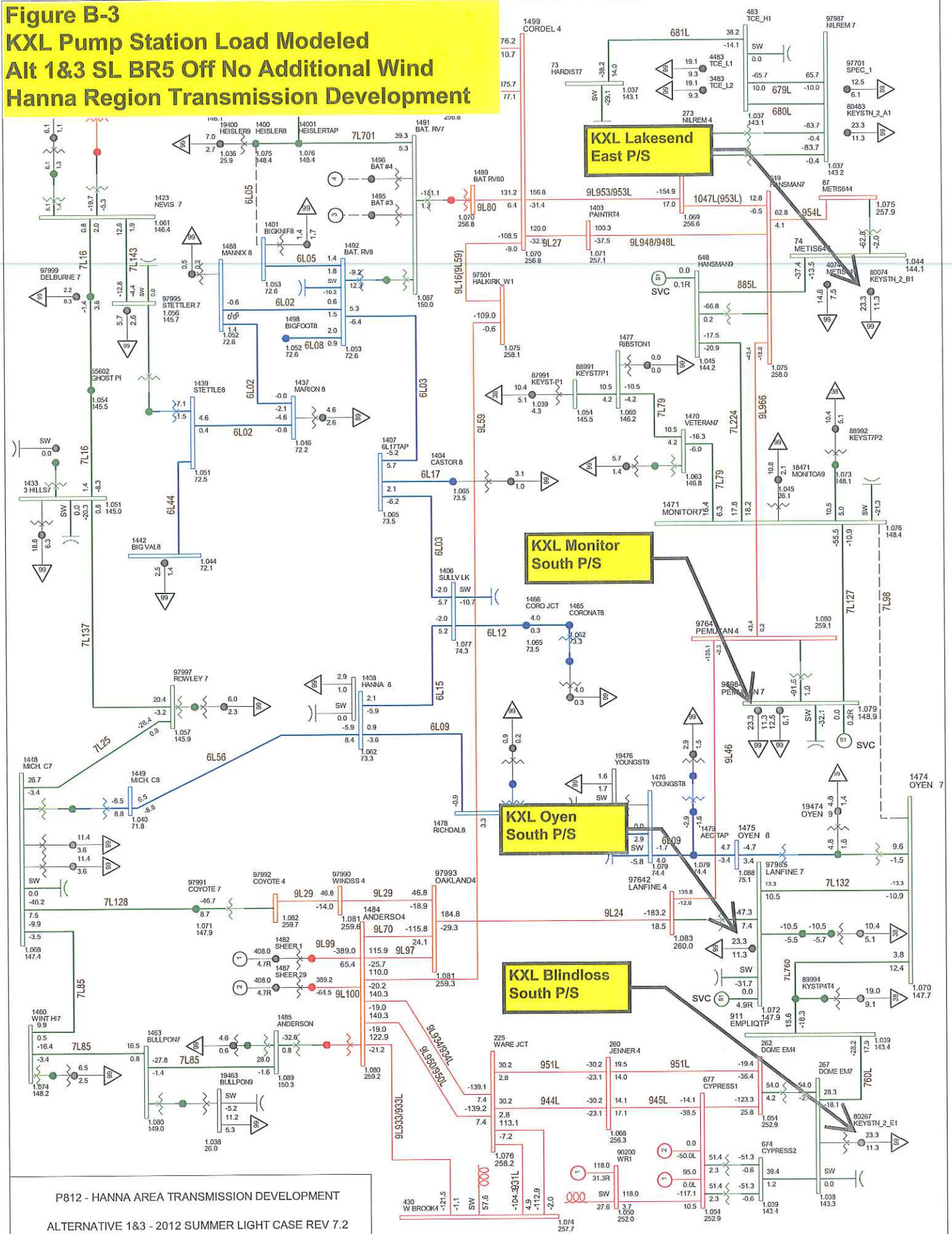


Figure B-4
KXL Pump Station Load Modeled
Alt 1&3 WP BR5 On 175MW Additional Wind
Hanna Region Transmission Development

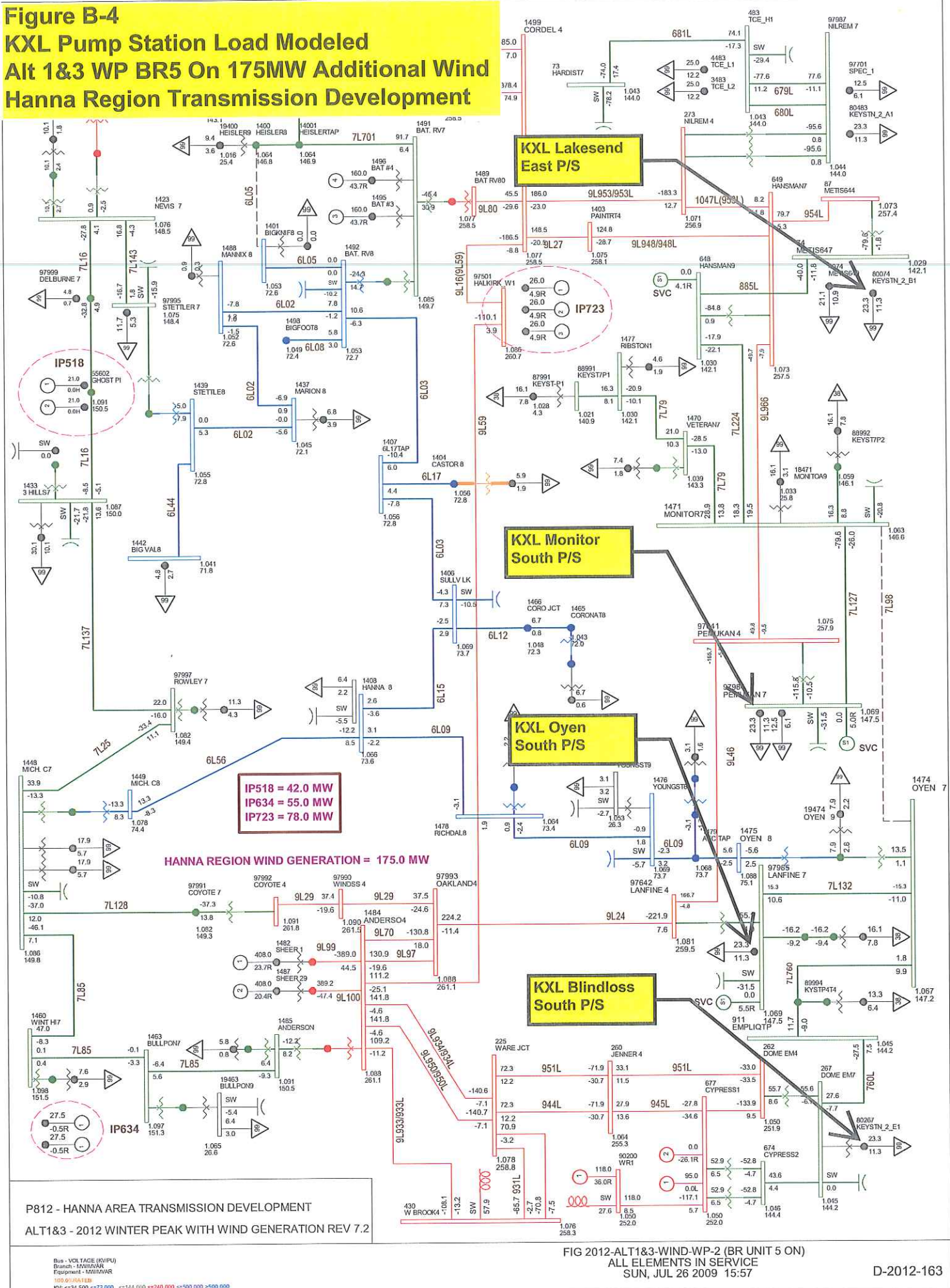


Figure B-5
KXL Pump Station Load Modeled
Alt 1&3 SP BR5 On 175MW Additional Wind
Hanna Region Transmission Development

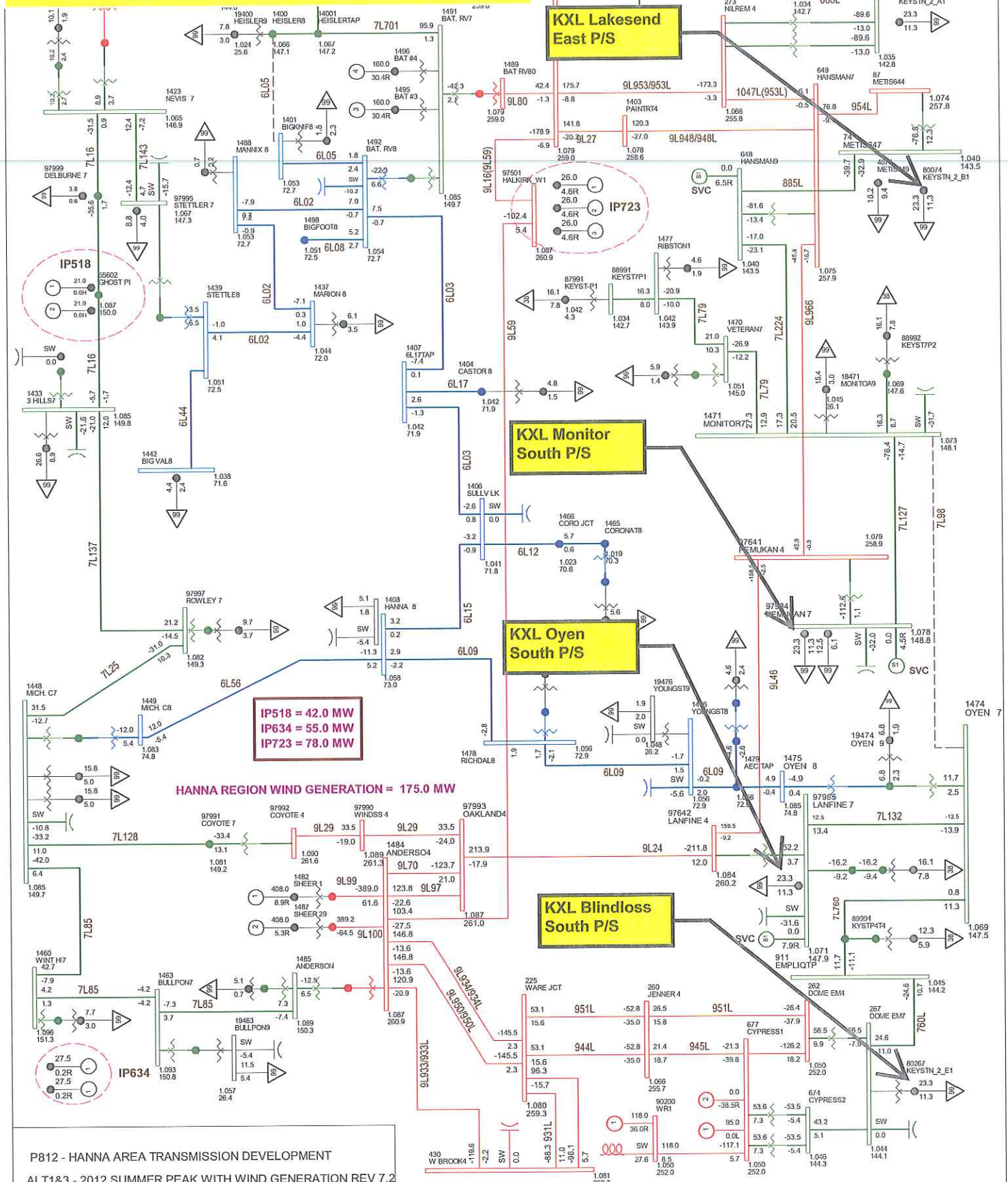


FIG 2012-ALT1&3-WIND-SP-2 (BR UNIT 5 ON)
 ALL ELEMENTS IN SERVICE
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Figure B-6
KXL Pump Station Load Modeled
Alt 1&3 SL BR5 On 175MW Additional Wind
Hanna Region Transmission Development

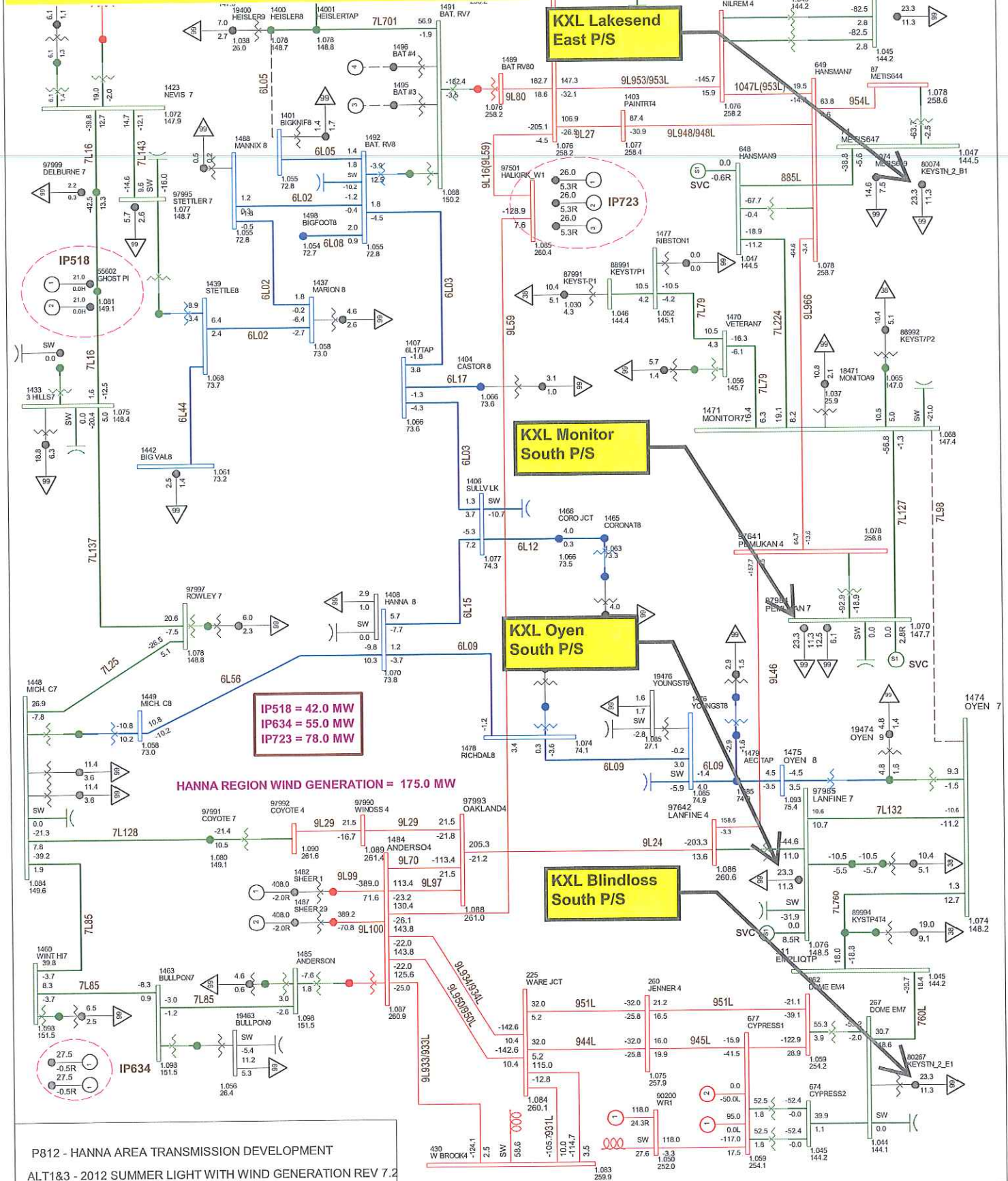


FIG 2012-ALT1&3-WIND-SL-2
 ALL ELEMENTS IN SERVICE
 SUN, JUL 26 2009 15:41