SUSITNA HYDROELECTRIC PROJECT

ELECTRIC POWER SYSTEM STUDY

TASK 7

Volume One

SYSTEM DEVELOPMENT AND STEADY STATE ANALYSIS

OCTOBER 1983

HARZA-EBASCO
SUSITNA JOINT VENTURE

ALASKA POWER AU

SUSITNA HYDROELECTRIC PROJECT

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TASK 7

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SYSTEM DEVELOPMENT
AND
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OCTOBER 1983

ELECTRIC POWER SYSTEM STUDY FOR THE SUSITNA
HYDROELECTRIC PROJECT

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INTRODUCTION

ELECTRIC POWER SYSTEM STUDY FOR THE SUSITNA
HYDROELECTRIC PROJECT

1 INTRODUCTION

This report is a summary of the electric power system planning studies of the Susitna Project conducted by Harza-Ebasco in September of 1983.

The purpose of the system planning studies was to identify possible refinements to the transmission plans described in the Federal Energy Regulatory Commission license for the project, in light of the most recent Railbelt load forecasts and anticipated conditions in the affected areas. Appendix A summarizes the current load forecasts for the Fairbanks and Anchorage Areas. Appendix B outlines anticipated generation development and retirement plans by area.

At this time, only steady-state (load flow) analysis of the refinements has been completed, but probable transient stability consequences have been recognized in limiting and ranking the alternatives for consideration. Transient stability studies will be used in a subsequent phase of the studies to identify the required amount of dynamic reactive compensation. Otherwise, these studies are not expected to impact the ranking of alternatives or their configurations.

In the course of the studies the planning criteria used have provided for acceptable performance following the failure of any single transmission element. The element may be a circuit, transformer, bus, static VAR compensator, generator unit or circuit breaker. Voltage levels at major buses were not allowed to drop more than five percent in steady-state. That was not a problem, given the extensive use of static VAR compensation.

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The system was also designed to be energizable from either Fairbanks or Anchorage to Susitna or from Susitna outward. Sufficient shunt reactor and static VAR compensation has been provided to avoid open-circuit voltages of greater than 110% of nominal, and even these are expected to be only of short duration.

Where questions involving the ratings of existing facilities arose, information provided by the utility owning the facility was used, whenever it was available.

The limited time allotted for the studies and this report did not permit complete documentation of the performance of each alternative discussed. However, performance of the preferred alternatives is described in Appendix C and referenced in the text of the report.

The following three chapters of this report discuss performance of transmission alternatives in the Susitna area, the Susitna-Fairbanks area and the Susitna-Anchorage area, respectively. Chapters 5 and 6 describe other aspects of the preferred alternatives.

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SUSITNA AREA SUBSYSTEM

2 SUSITNA AREA SUBSYSTEM

2.1. Description of Conditions

The goal of the transmission system in the Susitna area is to collect the power output of Watana (750 MW), Devils Canyon (600 MW) and the Reregulation Dam (75 MW). Watana and the Reregulation Dam are scheduled for 1993 service and Devils Canyon would follow in about 2002.

Geographically the output of all three plants must be transmitted in a westerly direction to connect with the preexisting 345 kV Intertie connecting Anchorage and Fairbanks. No other transmission will exist in the area before Susitna is developed. The distances from the Intertie to the Reregulation Dam, Devils Canyon and Watana are 4, 8 and 34 miles, respectively.

2.2 The Preferred Plan

The preferred plan of development would initially connect Watana to a switching station at Gold Creek with two 345 kV circuits. This would also be the junction to the preexisting 345 kV Intertie. The Reregulation Dam would be connected initially to one of the circuits and a 345 kV switching station, developed later at Devils Canyon, would switch it into both 345 kV circuits.

Detailed load flow diagrams are presented in Appendix C.

Maximum power flows on the two 345 kV circuits to Gold Creek would increase from 750 MW at Watana to 1425 MW at Gold Creek. A single 345 kV circuit is able to carry these flows during contingency conditions, although greater conductor sag allowances than are planned for the Intertie 345 kV circuit will be required for the portions between Devils Canyon and Gold Creek.

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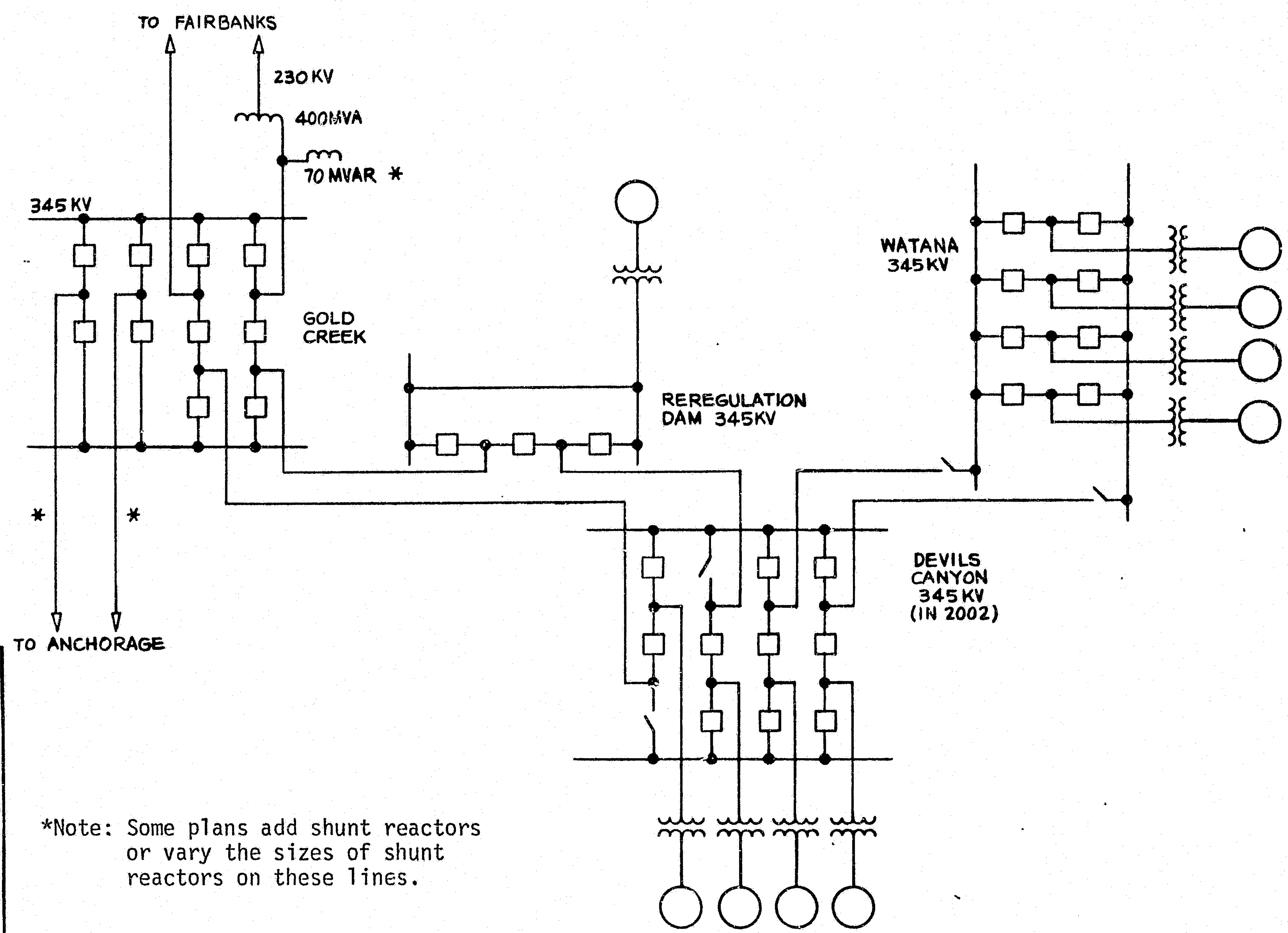
The preferred configuration and associated 345 kV switching are shown in Figure 2.1. The switching at Watana requires eight circuit breakers in a double-breaker arrangement. The double-breaker arrangement is required to prevent a circuit breaker failure from simultaneously tripping two of the generating units. Watana's capacity is large enough that at times it could serve about 90% of the Railbelt load. Loss of two units could create a generation deficiency equal to as much as 45% of the Railbelt load. A blackout could result if load-shedding procedures are unable to cope with such a large deficit. The proposed switching arrangement is intended to minimize that possibility.

At the Reregulation Dam a three-circuit-breaker ring is adequate to both protect the units, and allow circuit breaker maintenance without interrupting one of the major exits from Watana and Devils Canyon. If multiple units are installed, their sizes would be small enough to allow tripping of all units for a fault of one. No additional 345 kV circuit breakers would be installed, but manual switching could allow isolation of the impaired unit and restoration of the other(s).

Switching at Gold Creek would involve partially double-breaker and partially breaker-and-a-half arrangements. An outage of either of the two 345 kV circuits to the south is regarded as the most critical system condition from a transient stability viewpoint. The proposed arrangement will prevent a circuit breaker failure on either line from affecting any other line.

The circuits to the north, particularly in the early phases of development, are less critical and are switched in the same bays as the Watana circuits, where a circuit breaker failure could trip two circuits. This saves two circuit breakers, compared to the alternative double-breaker arrangement. By the time the northern circuits are heavily loaded, a breaker failure would affect only an additional eight mile line section to the Devils Canyon switching station. Static compensation planned for other events will be able to cope with that event as well.

SUSITNA AREA
SWITCHING DIAGRAM
(PREFERRED PLAN)



*Note: Some plans add shunt reactors
or vary the sizes of shunt
reactors on these lines.

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SUSITNA HYDROELECTRIC PROJECT

FIGURE 2.1

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Switching at Devils Canyon is proposed to be in a breaker-and-a-half arrangement to switch one generator unit and one circuit in each of the four bays. It is possible to omit two circuit breakers, as shown, by using the two buses to switch the circuits to Gold Creek. Those two circuits are the only exits from both Watana and Devils Canyon, so it is immaterial whether both buses could be tripped if both circuits were tripped.

2.3 Other Alternatives Considered

One major alternative to the preferred plan has been considered. It would eliminate the Gold Creek switching station and route all circuits into Devils Canyon. Combination of the two stations on one site is judged to be able to save about eight 345 kV circuit breakers at the time of development of Devils Canyon. However, offsetting this savings would be the need to construct an additional 16 miles of 345 kV and/or 230 kV circuitry in 1993. On a present worth basis the two choices can be regarded as nearly equal in cost. The Devils Canyon site would result in greater line lengths for the critical circuitry to both the north and south. The costs of additional dynamic compensation to restore comparable performance is judged to tip the balance toward use of the Gold Creek site. Additional benefits include lower right-of-way requirements and lower initial costs.

Another minor variation which could be made to the preferred plan would be to provide lower voltage switching, perhaps 138 kV, at Watana, and connect to the two outgoing 345 kV circuits with two 900 MVA transformers. This would have only a minor impact on performance, but could result in lower equipment costs and/or reduced clearance requirements at the power house. Detailed engineering studies will be required to determine if such a change would be advantageous.

SUSITNA TO FAIRBANKS SUBSYSTEM

3 SUSITNA TO FAIRBANKS SUBSYSTEM

3.1 Description of Conditions

The function of the transmission system between Gold Creek and Fairbanks will be primarily to deliver Susitna power to Fairbanks over a distance of about 190 miles. It is expected that all of the load in the Fairbanks area will be served from Susitna, unless some generation is provided on line as spinning reserve.

Load forecasts for the Fairbanks area indicate that transmission requirements will increase from about 175 MW in 1993 to approximately double that level, nearly 350 MW, by about 2020, including transmission losses.

The preexisting Intertie is the only transmission expected to exist in the area before Susitna is developed. It will consist of a 345 kV circuit reaching north to Healy, which is about half way to Fairbanks, and a 138 kV circuit with a summer sag rating of about 80 MW extending over the balance of the distance. Relatively small amounts of static compensation will be connected to the 138 kV system at Healy and Fairbanks.

3.2 The Preferred Plan

Initial studies of potential transmission systems between Susitna and Fairbanks have indicated that plans utilizing either 345 kV or 230 kV, each consisting of two circuits, would be able to serve the year 2020 forecast load. Because of substantial cost savings, a basically 230 kV plan with one intermediate switching station is recommended.

The plan recommended consists of the preexisting 345 kV Intertie and a 230 kV circuit between Gold Creek and Healy. The Intertie may operate at either 345 kV or 230 kV, but, for reasons given later, 345 kV is recommended. In any event, a 400 MVA 345/230 kV transformer would be provided for each of the two circuits.

From Healy to Fairbanks two 230 kV circuits would be built. Switching at 230 kV would be provided at Healy. Since 138 kV is expected to be used for local needs at Fairbanks, transformation from 230 kV to 138 kV would be provided at the Fairbanks end, called Ester Substation. In order to minimize costs, switching would be at 138 kV.

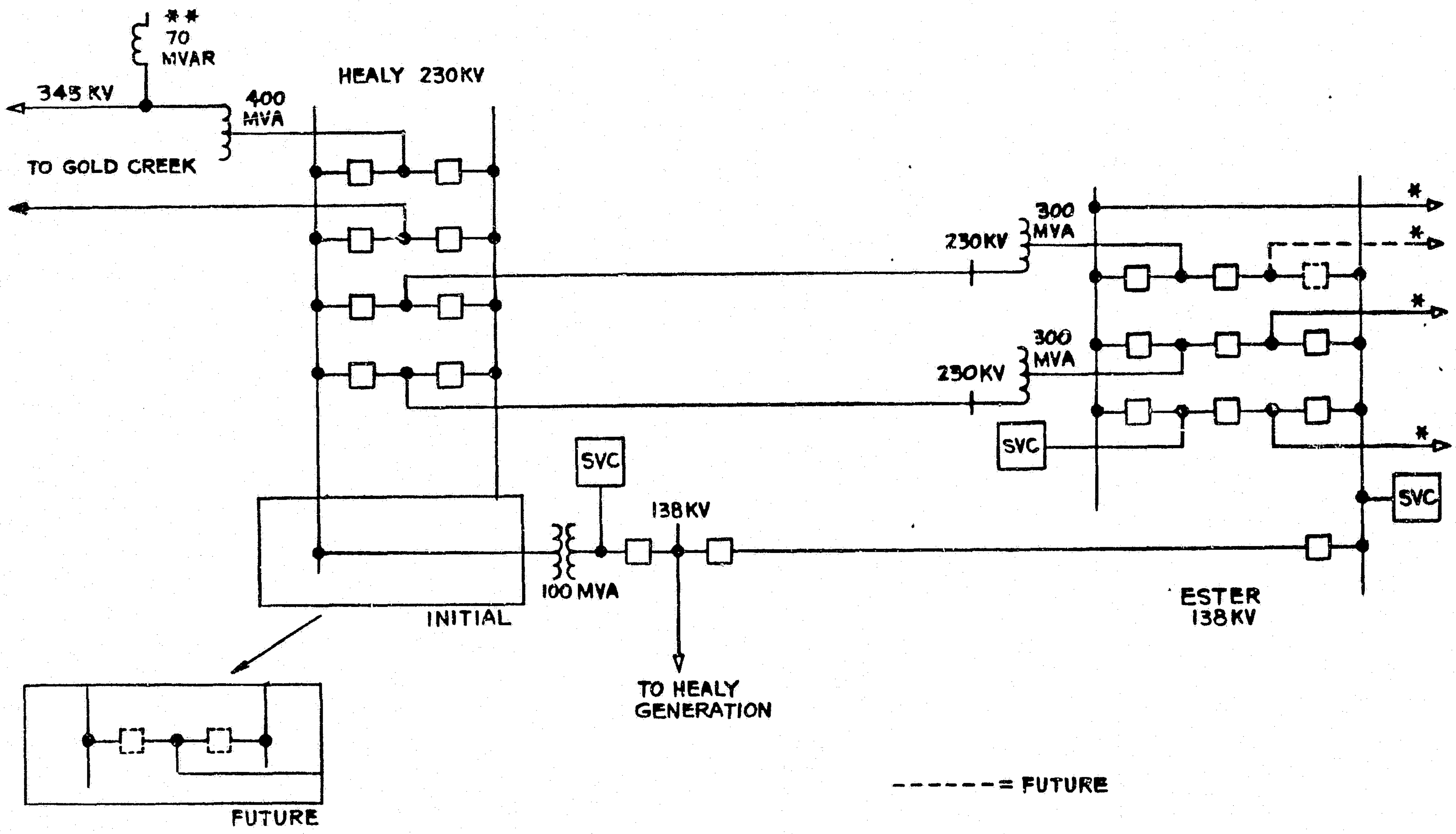
Load flow performances of this alternative are shown in Appendix C.

The switching diagram of the preferred alternative is shown in Figure 3.1. Only the switching at Healy and Ester is expected to change over the study period. The changes at Healy are to increase reliability of the 138 kV circuit which parallels the 230 kV lines. The changes at Ester would be associated only with 138 kV local additions in Fairbanks.

At the Healy end of the 345 kV circuit and at the Gold Creek end of the 230 kV circuit, 70 MVA shunt reactors would be installed. The one connected to the 230 kV circuit constitutes over-correction of line charging on that particular segment. Since some compensation of the 230 kV is required to allow energization from Fairbanks, within acceptable open-ended voltage limits at Gold Creek, it was felt best to use a common reactor size on all circuits. The lack of shunt reactors on many of the other circuits makes large reactors desirable.

A double-breaker switching arrangement is required at Healy to avoid the simultaneous loss of an incoming and an outgoing line, or two of either, in case of a circuit breaker failure. A 100 MVA 230/138 kV transformer (which could be relocated from Teeland) should be installed initially at Healy to gain access to the static compensation located on the Healy 138 kV bus. Alternatively, the Healy SVC could be connected to the tertiary of the 100 MVA transformer. During the initial years of operation, the 230/138 kV transformer can be connected directly to one of the 230 kV buses. However, toward the end of the study period it should be given independent double-breaker switching to prevent a breaker failure from tripping both a 230 kV circuit and the source to the parallel

GOLD CREEK-FAIRBANKS
SWITCHING DIAGRAM
(PREFERRED PLAN)



*To Fairbanks Area 138kV
**Some plans vary the size of shunt reactors

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SUSITNA HYDROELECTRIC PROJECT

FIGURE 3.1

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138 kV circuit. This schedule provides a cost-effective alternative to increasing the static compensation as would otherwise be required during later years.

At Ester, two additional static compensation systems will be required for partial redundancy. Their sizes are estimated in Chapter 5 of this report and will be determined more accurately by the transient stability studies.

Switching at Ester may be accomplished with a breaker-and-a-half configuration, provided that no breaker failure results in loss of one of the 230/138 kV transformers simultaneously with the loss of either the Healy 138 kV circuit or a static compensator. If it will not be possible to accomplish this, a partial double-breaker layout will be required.

3.3 The All 230 kV Alternative

Three variations on the preferred plan have been considered.

The first would shift the 345/230 kV transformer from Healy to Gold Creek to allow operation of both circuits north of Gold Creek at 230 kV. The benefit obtained from this move would be to have both 345/230 kV transformers in the same station, which could be an advantage from maintenance or station access point of view. Furthermore, it could also facilitate replacement of a failed transformer if a spare were located at Gold Creek.

The advantages which cause a preference for the Healy transformer location include reduced transmission losses, reduced static compensation requirements and superior transient performance for contingencies, including loss of the Gold Creek-Healy 345 kV circuit. The reason for the loss reduction benefit is that the impedance of the circuit operating at 345 kV is only 44% of its impedance at 230 kV. This reduces total line current loading by shifting it from the parallel single conductor 230 kV circuit to the double conductored 345 kV circuit, resulting in reduced losses.

The difference in impedances and the ability to change transformer taps on each circuit independently also allows a beneficial circulation of reactive power on the two Gold Creek-Healy circuits. If more reactive power flows from Healy into the Gold Creek 345 kV line than into the Gold Creek 230 kV line, the voltage effects of their respective outages can be nearly equalized at a particular (e.g., peak) load level. Without such circulation of reactive power, loss of the 345 kV circuit would always be a more severe contingency than the loss of the 230 kV circuit. In this case, the 345 kV outage would determine the static compensation requirements. However, by equalizing the two lines' outage effects at an intermediate level, the total amount of static compensation can be reduced.

Other minor benefits from 345 kV operation, though less important, would be to decrease flicker effects, and to allow the static compensation at Fairbanks to better support Susitna transient voltage levels for the more severe contingencies affecting the Anchorage area. These are due to the fact that the system impedance seen by Fairbanks would be smaller in this case.

Overall it is felt that the benefits of operating a line already designed for 345 kV at 345 kV offset the disadvantages of having two different 345/230 kV transformer locations, even if an additional spare is required, which is probably unwarranted anyway.

3.4 The Partial 138 kV Alternative

Another alternative which would utilize 138 kV circuitry north of Healy has been investigated, but is not recommended.

The construction of two additional 138 kV circuits north of Healy, to work in parallel with the existing circuit, would encounter contingency loading problems on the existing 138 kV circuit for all load levels above about 160 MW in the summer. An outage of one of the new circuits would load both the existing and the other new 138 kV circuit to about the same levels and be limited by the existing circuit's capability. Without reliable data on summer load levels forecast for Fairbanks, it is judged that the 138 kV alternative would reach its limit before the end of the study period.

The cost of an eventual fourth 138 kV circuit combined with higher static compensation requirements, higher losses, additional right of way requirements and dubious transient stability performance is judged to outweigh the initial line cost savings which might be obtained by use of the lower voltage level.

3.5 The All 345 kV Alternative

The alternative of having just two 345 kV circuits between Gold Creek and Fairbanks with transformation to 138 kV at Fairbanks has been briefly considered. While it would allow elimination of the intermediate switching station at Healy, its line costs are unreasonably high compared to the 230 kV versions. It is also apparent that 345 kV circuits with capabilities in excess of 1000 MW are not justified for normal loadings of 85 to 175 MW per circuit over the study period.

SUSITNA TO ANCHORAGE SUBSYSTEM

4 SUSITNA TO ANCHORAGE SUBSYSTEM

4.1 Description of Conditions

The transmission system between Susitna and Anchorage is expected to carry the bulk of Susitna's power output over a distance of about 150 miles. Essentially all the power not required to serve Fairbanks will flow to Anchorage, up to the limit of the Anchorage load. Under these conditions loadings southward are expected to be as high as 650 MW in 1993 and to decline slightly (as Fairbanks' share increases) until Devils Canyon is built. After Devils Canyon is in service, peak loadings could increase to nearly 800 MW and will grow with the Anchorage load until Susitna's capacity is fully utilized. With current load forecasts, transfers to the south could peak at about 1100 MW in year 2015. Thereafter they are expected to decline, as a greater share of Susitna's output will flow towards Fairbanks. Should spinning reserve be maintained at Susitna, flows to the south would peak at a lower level.

Prior to the development of Susitna, only the southern end of the Anchorage-Fairbanks Intertie is expected to exist in this corridor. It will consist of a 345 kV circuit extending south to Willow Station (about half way to Anchorage) plus an additional 25 miles of 138 kV line to Teeland Station and 23 miles of 230 kV line to Point McKenzie Station. From Point McKenzie, 138 kV and 230 kV cables under Knik Arm, having combined ratings of just over 600 MW, connect both the Intertie and Chugach Electric Association's Beluga Power Plant (rated in excess of 300 MW) to Anchorage.

For purposes of this study it has been assumed that all power deliveries from Susitna, with the exception of about ten percent of the area load now served from west of Knik Arm, must be delivered to east of Knik Arm. Furthermore, it has been assumed that no more than one new 230 kV or 345 kV circuit can be constructed around the north end of Knik Arm.

4.2 Similarities and Differences: A Summary

Unlike the other two transmission areas described, the Susitna-Anchorage transmission system has several alternatives which could be competitive. Their ranking in order of preference could change if additional information or restrictions are discovered. In this report the four most favorable alternatives are analyzed in more detail than the others, to aid in possible re-ranking should this become necessary in the future.

All of the alternatives are based on the use of two 345 kV circuits running southward towards Anchorage, and terminating in an Anchorage area 230 kV system.

In each case one of the 345 kV circuits is routed around Knik Arm into Anchorage. Transformation of this circuit to 230 kV has been assumed at the Fossil Creek site, although termination at Anchorage Municipal Power's Generating Station 2 could also be acceptable if access for incoming and outgoing circuitry proves to be adequate.

The second 345 kV circuit, depending on the alternative chosen, ends at one of three locations: at W/T (a location between Willow and Teeland), at Lorraine (in the area of the west end of the 230 kV Knik Arm cable crossing), or at Fossil Creek. In some cases this second 345 kV circuit is to be extended in stages.

The alternatives also share the need for an intermediate 345 kV switching station at either Willow or W/T, in addition to a few hundred MVAR of dynamic shunt reactive compensation. Use of the latter is judged to be a less expensive approach to cope with the peak power transfers of nearly 1100 MW when compared to the addition of a third 345 kV circuit. Shunt reactors would also be installed at Gold Creek or W/T on both 345 kV circuits.

All of the more favorable alternatives plan to use the existing Chugach Electric Association's Knik Arm cable crossings to a maximum extent in the initial stages of the project. Subsequent additions to cable capacity are then made at 230 kV or 345 kV levels, depending upon the alternative. The timing of the addition is dependent upon how Anchorage area generation is expected to be dispatched and the extent to which operating procedures during contingencies become acceptable means of deferring the very substantial cost of the cable crossing. These variations and the possible differences in costs and the ultimate capabilities of 230 kV and 345 kV cables play significant roles in selecting the preferred alternative.

All of the preferred alternatives accomplish two local Anchorage objectives. They are that the Teeland area of Matanuska Electric Association will be provided with two-way 230 kV service and that Point McKenzie will be tied to the remainder of the system by two 230 kV circuits in addition to the existing 138 kV cables. The former is believed necessary to allow reliable power delivery to Matanuska Electric Association. The latter is believed necessary to maintain the stability of the Beluga Plant, once Anchorage is tied to Susitna. The ways in which these two goals are accomplished also play a role in ranking the alternatives.

One final similarity of each plan is that the urban Anchorage area transmission system will require rearrangements, and additional circuits from Fossil Creek into the urban area and/or its southern periphery. Most of these changes have not been studied in detail and will depend upon local constraints. However, one improvement which is necessary in all alternatives is the addition of phase shifting transformers to control loadings of the Knik Arm 138 kV cables. The addition of these phase shifters is essential to allow all Knik Arm cables to be loaded simultaneously to their individual maximums and to prevent overloading of the 138 kV cables.

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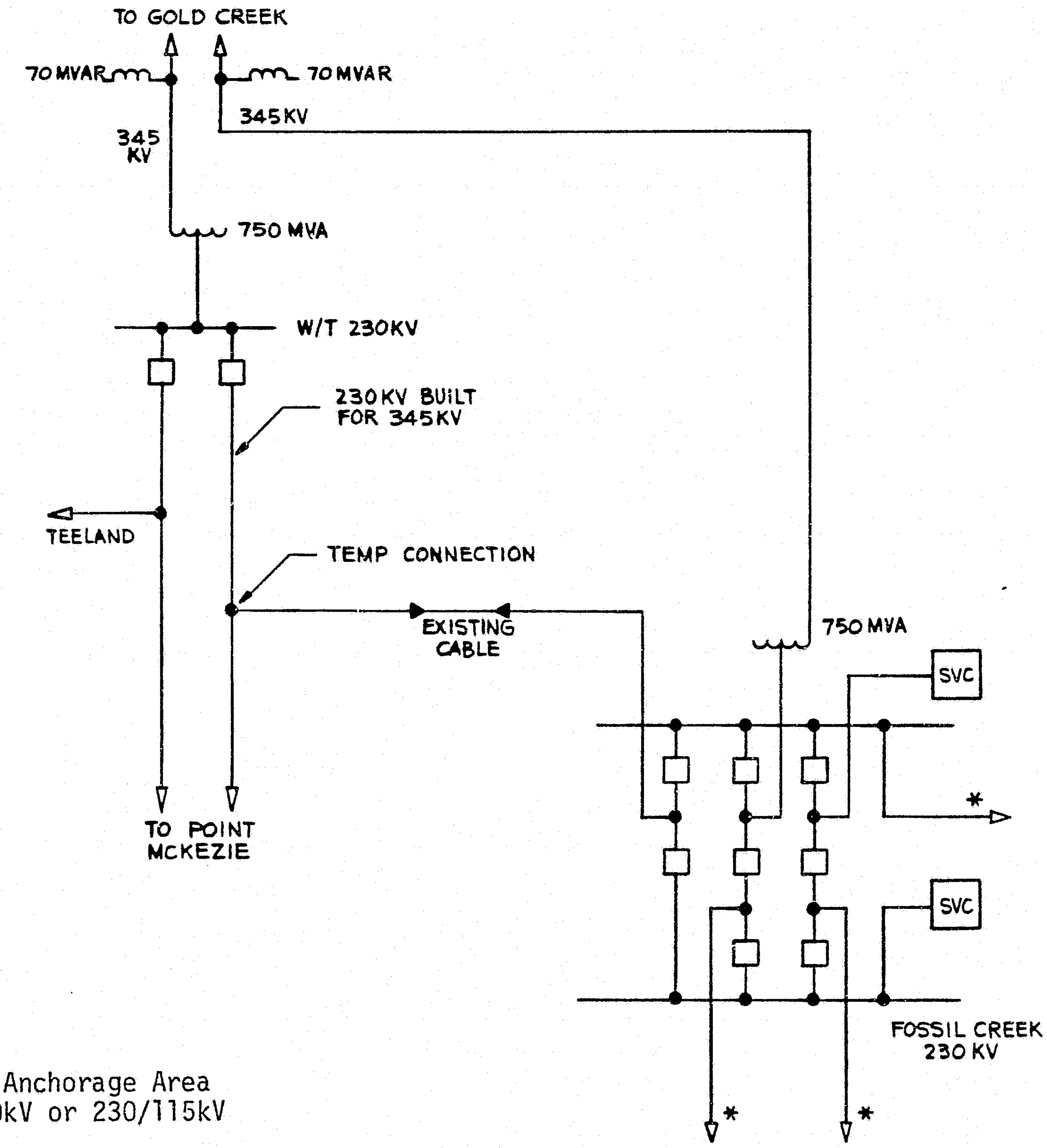
Details of each alternative are described separately. As the project developed, alternatives were assigned sequential letters of the alphabet. In order to keep track of the background material and enable us to locate data quickly in the future, it was decided that this alphabetic designation should also be kept in the present report. Therefore, the letter designations of the different plans and alternatives have no current specific significance.

4.3 Plan Y

Plan Y is judged to offer the most flexibility for future development of the Anchorage area transmission system, to use the least amount of right of way and to have the lowest losses. It is the recommended plan at this time. Because it uses 345 kV underwater cable, rather than a lower capability and lower cost 230 kV cable, it may entail a slight cost premium over the least expensive plan. The cost premium is within the realm of estimation uncertainty of other alternatives.

A switching diagram for the initial (1993) development of Plan Y is shown in Figure 4.1. Detailed load flow diagrams are presented in Appendix C.

Transformation (750 MVA each) from 345 kV to 230 kV is provided at W/T and at Fossil Creek. Shunt reactors of 70 MVAR each are placed on both 345 kV lines at W/T. Two 230 kV lines originate from W/T: one goes to Teeland, and also provides power to the Matanuska Electric Association, the other is routed directly to the junction of the existing Knik Arm 230 kV cable crossing. The latter circuit is to be built for 345 kV operation. At a later time a 345 kV cable crossing would be installed and connected to this line.



*To Anchorage Area
230kV or 230/115kV

1993
ANCHORAGE AREA
SWITCHING DIAGRAM
(PREFERRED PLAN Y)

ALASKA POWER AUTHORITY
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FIGURE 4.1

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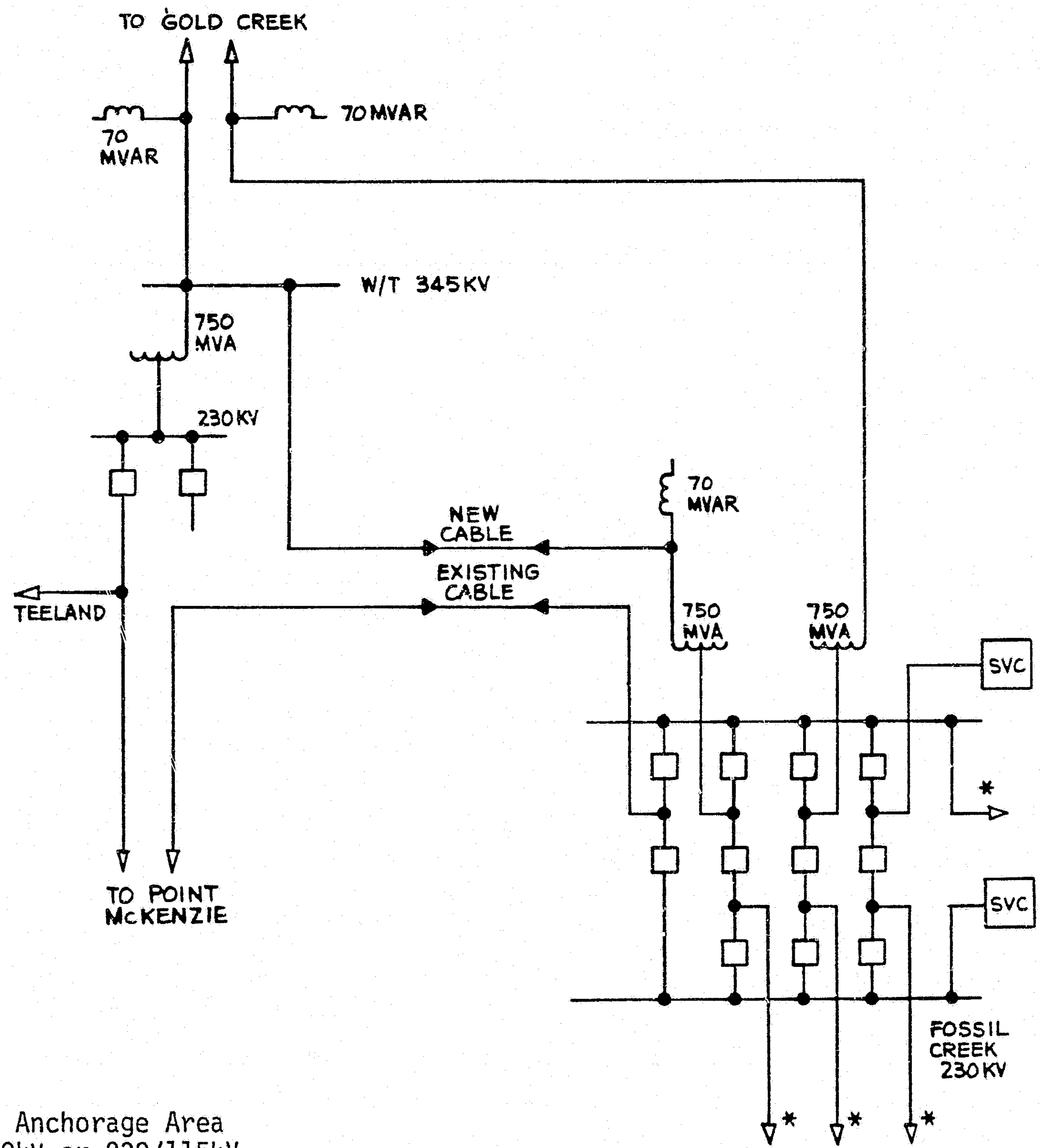
SUSITNA JOINT VENTURE
ANCHORAGE, ALASKA

Switching at the W/T 230 kV bus would consist of just two 230 kV line breakers, unless Beluga's stability, which will be analyzed during the transient studies, requires more breakers. At the 230 kV cable junction it is recommended that manual switching be provided, and that a three terminal Point McKenzie-W/T-Fossil Creek circuit be established. The reason for omitting a switching station at this location is that it would become useless once the circuit is converted to 345 kV operation in less than ten years.

At Fossil Creek a breaker-and-a-half arrangement consisting of at least eight circuit breakers will be required to switch the 345/230 kV transformer, two static VAR compensators, the cable and the outgoing 230 kV lines or 230/115 kV transformers.

When additional Knik Arm cable capacity is needed, Plan Y would install a 345 kV cable, a 70 MVAR shunt reactor, and another 750 MVA 345/230 kV transformer at Fossil Creek as shown in Figure 4.2. An additional line from Fossil Creek to Anchorage may also be required. The 345 kV line from W/T, which is initially operated at 230 kV, would be reconnected to the W/T 345 kV bus to complete the second Gold Creek-Fossil Creek 345 kV circuit. The three terminal 230 kV circuit would be eliminated, but a 345 kV line with W/T as a solid tap would replace it. Three 230 kV circuit breakers would be added at Fossil Creek and one would be released at W/T. A variation of this sequence could defer the 345/230 kV transformer by operating the new cable and shunt reactor at 230 kV for a period of time.

The timing of this addition could be about 1999 or whenever power transfer across Knik Arm cables and on the overhead 345 kV circuit into Fossil Creek exceeds the estimated 625 MW cable capacity. The limitation is in the cables themselves for an outage of the 345 kV circuit into Fossil Creek. Since the cables have a time constant of several hours, any post-contingency operating procedure which would substitute generation east of Knik Arm (Anchorage and/or Kenai) for Susitna or Beluga generation could defer the need for adding the 345 kV cable, possibly until the second Susitna stage. Should a highway bridge across Knik Arm be in the planning stage by this time, cable ducts should be included in its design.



*To Anchorage Area
230kV or 230/115kV

ABOUT 1999
ANCHORAGE AREA
SWITCHING DIAGRAM
(PREFERRED PLAN Y)

ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

FIGURE 4.2

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ANCHORAGE, ALASKA

When the second Susitna stage is added in about 2002, Alternative Y would add 345 kV switching at W/T. It would also complete the 345 kV cable, if not done earlier. This addition removes the 750 MVA transformer restriction in power transmitted to Anchorage and reduces the impact of a 345 kV line outage by reducing circuit lengths. This configuration is adequate for transmission of the maximum expected Susitna output, with only the addition of another static VAR compensator at W/T 230 kV. The latter might be required by the year 2010; timing will depend on transient stability studies.

A switching diagram of the W/T station with the latter two additions is shown in Figure 4.3. The 345 kV bus is arranged in a double-breaker layout. A double-breaker layout of 10 circuit breakers is required for breaker failure protection. This avoids the loss of two 345 kV lines, or two 345/230 kV transformers, or a line and the 345/230 kV bank to the static VAR compensator. On the 230 kV bus a three breaker ring is adequate to switch the three elements.

One of the major advantages of Plan Y is that as Susitna's capacity becomes fully utilized, it does not require the use of all of the existing Knik Arm cable capacity. Even during a contingency, it is unlikely that the 138 kV and 230 kV cables would have to carry more than 300 MW combined. This means that it will be possible to generate in excess of 300 MW at Beluga or a replacement power plant west of Knik Arm, without adding cable capacity. Effectively, the firm cable capacity which Chugach Electric Association has currently installed would be largely restored for its use by the time it would be needed to integrate another power plant. Another interpretation is that retirements of the aging 138 kV cables could be tolerated from a bulk transmission point of view.

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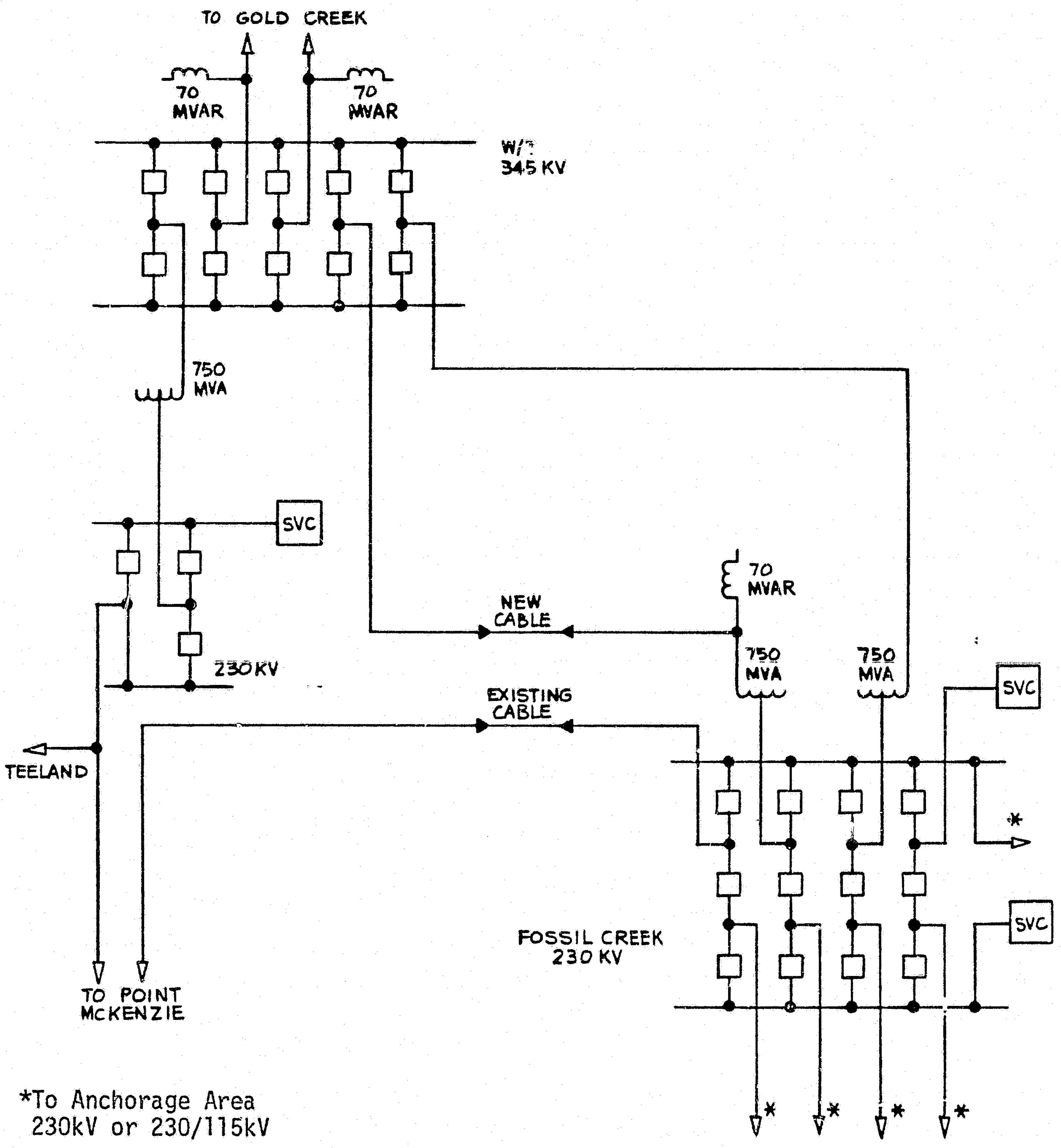

*To Anchorage Area 230kV or 230/115kV

ULTIMATE
ANCHORAGE AREA
SWITCHING DIAGRAM
(PREFERRED PLAN Y)

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FIGURE 4.3

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ANCHORAGE, ALASKA

Another advantage of this plan is that W/T is sited to allow at least one more 230 kV exit to be developed which would improve overall area reliability. The Knik Arm cable limitations may be further reduced if Matanuska Electric Association can complete a 230 kV circuit around the north of Knik Arm to Fossil Creek by conversion of its existing 115 kV system. Such a circuit would allow more reliable service to the area north of Knik Arm and would act somewhat in parallel with the 138 kV and 230 kV Knik Arm cable crossings during an outage of either of the 345 kV circuits into Fossil Creek. The transformer at W/T is sized to allow this conversion to be made.

4.4 Plan K

Plan K differs from Plan Y in that only one 345 kV line extends beyond W/T. Capital costs are minimized by using 230 kV circuitry and cables as the second source to Anchorage. It has a slight capital cost advantage over Plan Y under some assumptions, but its end result is a system with greater losses, additional right of way requirements and limited ability to integrate additional generation west of Knik Arm. In fact, failures or retirement of Chugach Electric Association's 138 kV cables would require generation curtailments unless replacement cables are added. Should another, third, 230 kV cable be required before 2020, this plan would ultimately become more expensive than Plan Y. However, under some circumstances, such as eventual completion of a Matanuska Electric Association 230 kV line from W/T to Fossil Creek, it could provide satisfactory performance.

The initial (1993) stage of Plan K is identical in configuration and switching to Plan Y. The only difference is that the 230 kV line from W/T to the 230 kV cable junction would be built for 230 kV only. This would result in a slight loading shift and slightly higher losses when compared to Plan Y. However, circuit costs would be lower in this stage.

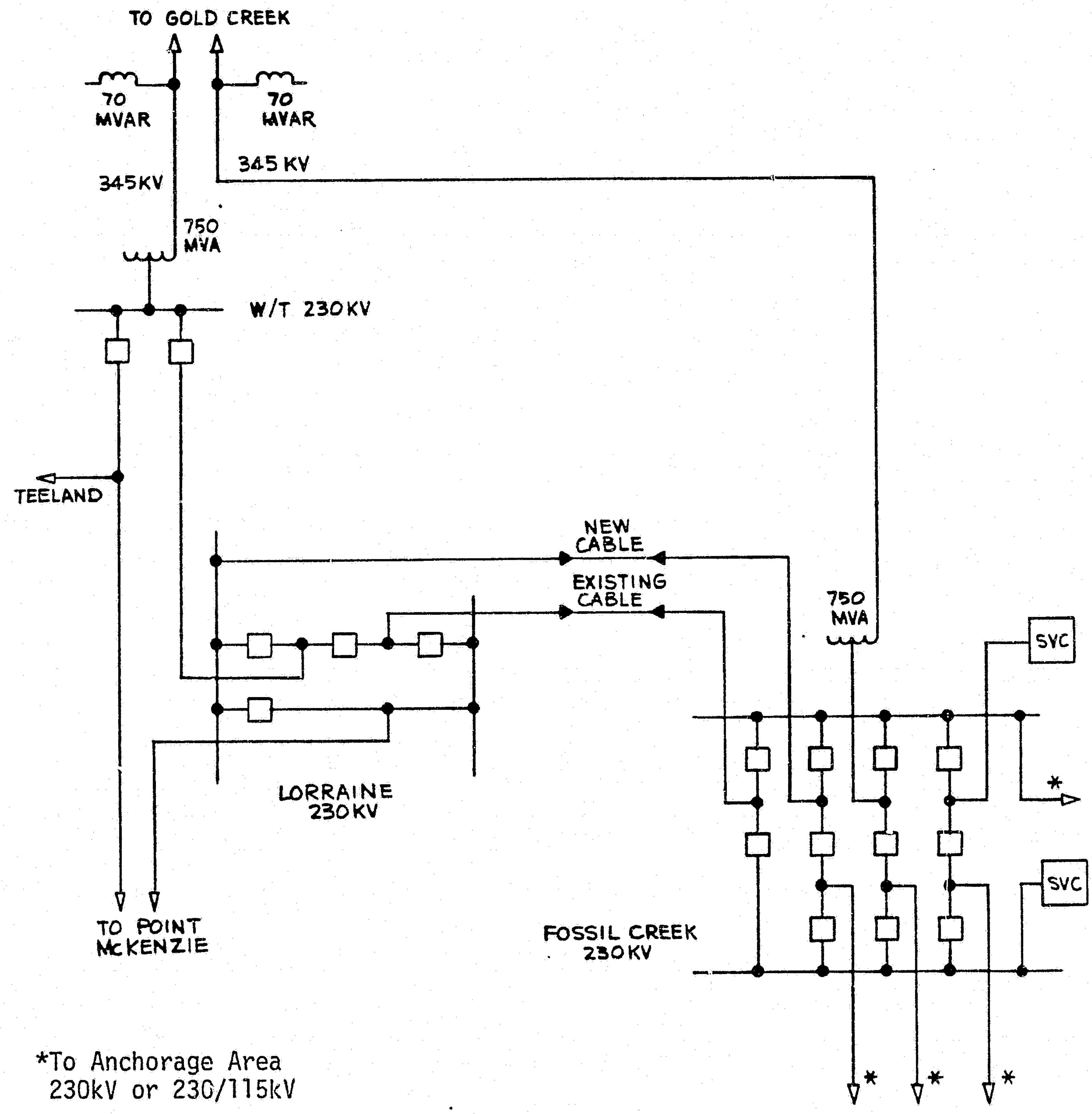
When additional Knik Arm cable capacity is needed, timed exactly as in Plan Y, a 230 kV cable would be installed. A switching station would also be constructed at the Lorraine site near the west end of the 230 kV cable crossing.

Switching for Plan K at this stage is shown in Figure 4.4. Note that no additional 345/230 kV capacity is required at this time, since W/T and Fossil Creek banks are still adequate. A switching station might be constructed at Lorraine when the circuit from W/T is first built, but for consistency with Plan Y, it has been deferred to the later date.

The capacity of the new 230 kV cable must be significantly higher, around 500 MVA, than the existing 230 kV cables; therefore, four single phase cables will have to be installed, just as for the 345 kV alternative. Ultimately a series reactor will be required in the existing 230 kV circuit to make it proportionately share load in parallel with the new cable, but it is not required until Susitna's loadings approach peak levels.

Switching at Fossil Creek would be identical to that of Plan Y, with the new 230 kV cable assuming a role corresponding to the second 345/230 kV transformer of Plan Y. Switching at Lorraine would be accomplished with a four breaker ring.

When the second phase of Susitna is developed (2002), Plan K would add 345 kV switching, another 750 MVA 345/230 kV bank at W/T, and more 230 kV switching. This would be followed, as loads increase, by the addition of another 230 kV circuit from W/T to Lorraine, a static VAR compensator at W/T and a series reactor in the existing 230 kV cable circuit.



*To Anchorage Area
230kV or 230/115kV

ABOUT 1999
ANCHORAGE AREA
SWITCHING DIAGRAM
(PLAN K)

ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

FIGURE 4.4

HARZA-EBASCO

ANCHORAGE, ALASKA

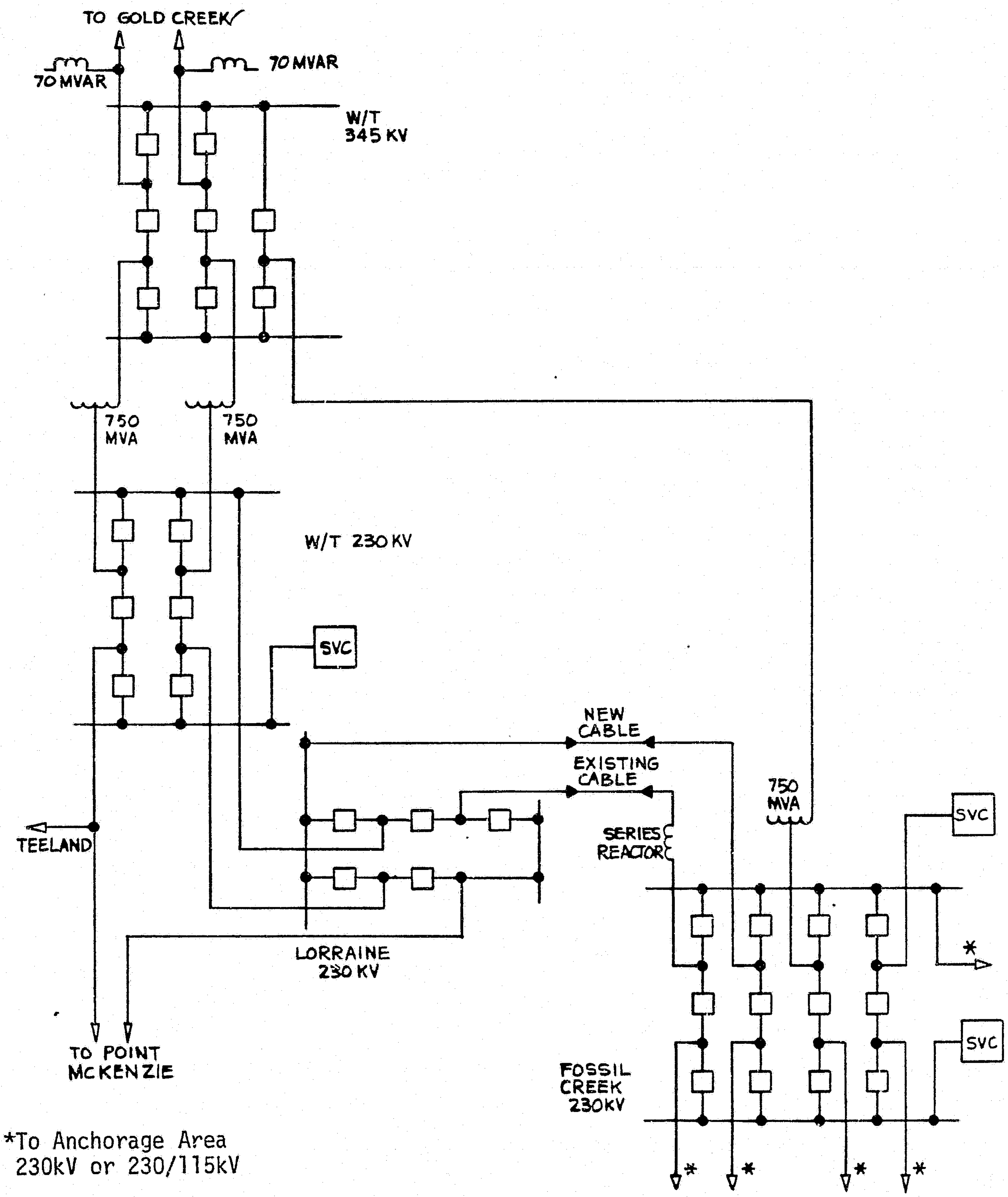
Switching for these additions is shown in Figure 4.5. The 345 kV and 230 kV switching at W/T is different from that of Plan Y. A breaker-and-a-half and double breaker layout is used at 345 kV. Fewer breakers are required to switch the same number of elements as in Plan Y, because here an outage of a transformer and a line to the north is tolerable for a breaker failure. On the 230 kV bus the switching is first expanded to a four element ring bus and later to a six element ring bus in a breaker-and-a-half layout. Lorraine can utilize a five circuit breaker ring bus, if arranged as shown.

4.5 Plan S

Plan S differs from Plan Y in that the second 345 kV line is initially terminated at Lorraine rather than W/T. This defers giving two way service to the Teeland area and makes Lorraine, instead of W/T, the major source station to the west side of Knik Arm. The Teeland-Point McKenzie circuit would be switched at Lorraine to provide a second circuit to Point McKenzie.

Figure 4.6 shows the initial (1993) switching diagram for Plan S. Lorraine would be developed in a five element ring bus configuration. Fossil Creek would have the same configuration as in the other alternatives, except its 345/230 kV transformer would be larger. An 1100 MVA rating would provide a reasonable match to maximum possible loadings and would still be within 3000 ampere switching capabilities at 230 kV. Shunt reactors of 50 MVAR would be placed at Gold Creek on each 345 kV circuit.

When additional cable capacity is needed, again with the same timing as Plan Y, a 345 kV cable would be extended into Fossil Creek and terminated in a 750-MVA 345/230 kV transformer. A 50 MVA shunt reactor would be placed at each end of the cable circuit. Switching for the second Fossil Creek transformer would be identical to that of Plan Y; that is, a solid tap on the 345 kV at Lorraine and the addition of three 230 kV circuit breakers at Fossil Creek.



ULTIMATE
ANCHORAGE AREA
SWITCHING DIAGRAM
(PLAN K)

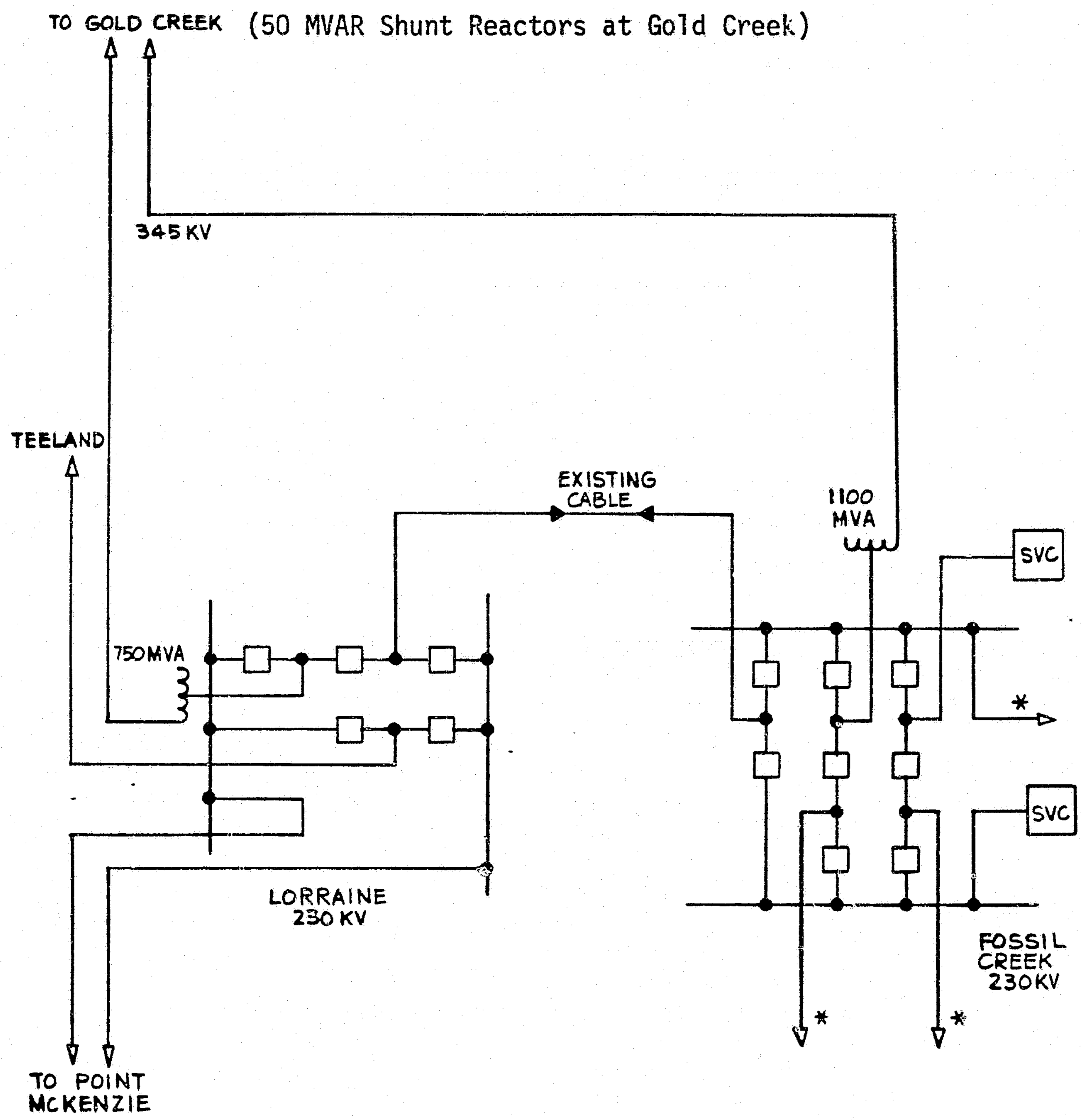
ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

FIGURE 4.5

HARZA-EBASCO

ANCHORAGE, ALASKA



*To Anchorage Area
230kV or 230/115kV

1993
ANCHORAGE AREA
SWITCHING DIAGRAM
(PLAN S)

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

FIGURE 4.6

HARZA-EBASCO

For the second Susitna stage no new transformation would be required. A 345 kV switching station would be developed at Willow, which, in this case, is a better location than W/T for reducing static VAR compensator requirements. As loads increase an additional static VAR compensator would be installed at Lorraine and another 230 kV circuit would be built to Teeland to provide two-way service.

A switching diagram of this final configuration is shown in Figure 4.7. At Willow the 345 kV switching would be a double-breaker configuration of eight breakers to avoid loss of two circuits for a single breaker failure. At Lorraine the seven elements to be switched would require expansion of the station to a breaker-and-a-half arrangement with at least eight circuit breakers.

4.6 Plan Q

Plan Q is very similar to Plan S, except that when additional cable capacity is needed, 230 kV cable would be used.

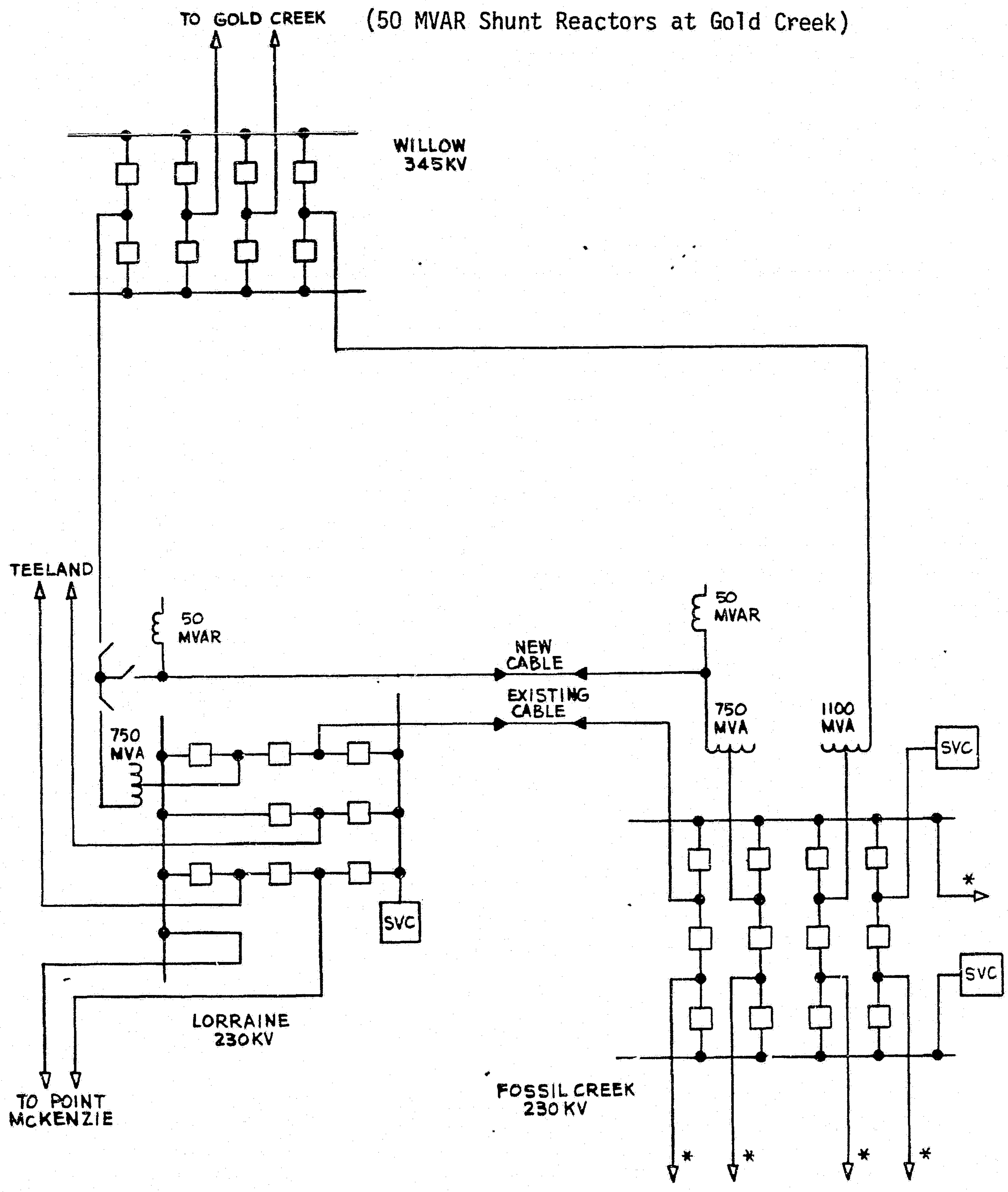
Since no new transformation would be added when the cable is added, the Lorraine transformer would be sized at 1100 MVA, the same rating as Fossil Creek's transformer.

Figure 4.8 shows a switching diagram of Plan Q in its final stages. Besides the cable, the only difference from Plan S is the addition of another 230 kV circuit breaker at Lorraine and a series reactor at Fossil Creek to aportion cable loadings.

4.7 Other Alternatives

Several other alternatives have also been considered. One variation includes the feature of initially completing two 345 kV circuits into Fossil Creek. Subsequent additions of 345/230 kV transformation at Lorraine or W/T would be required to be able to utilize the existing Knik Arm cable capacity to obtain adequate cable capacity into Anchorage.

4763B



*To Anchorage Area
230kV or 230/115kV

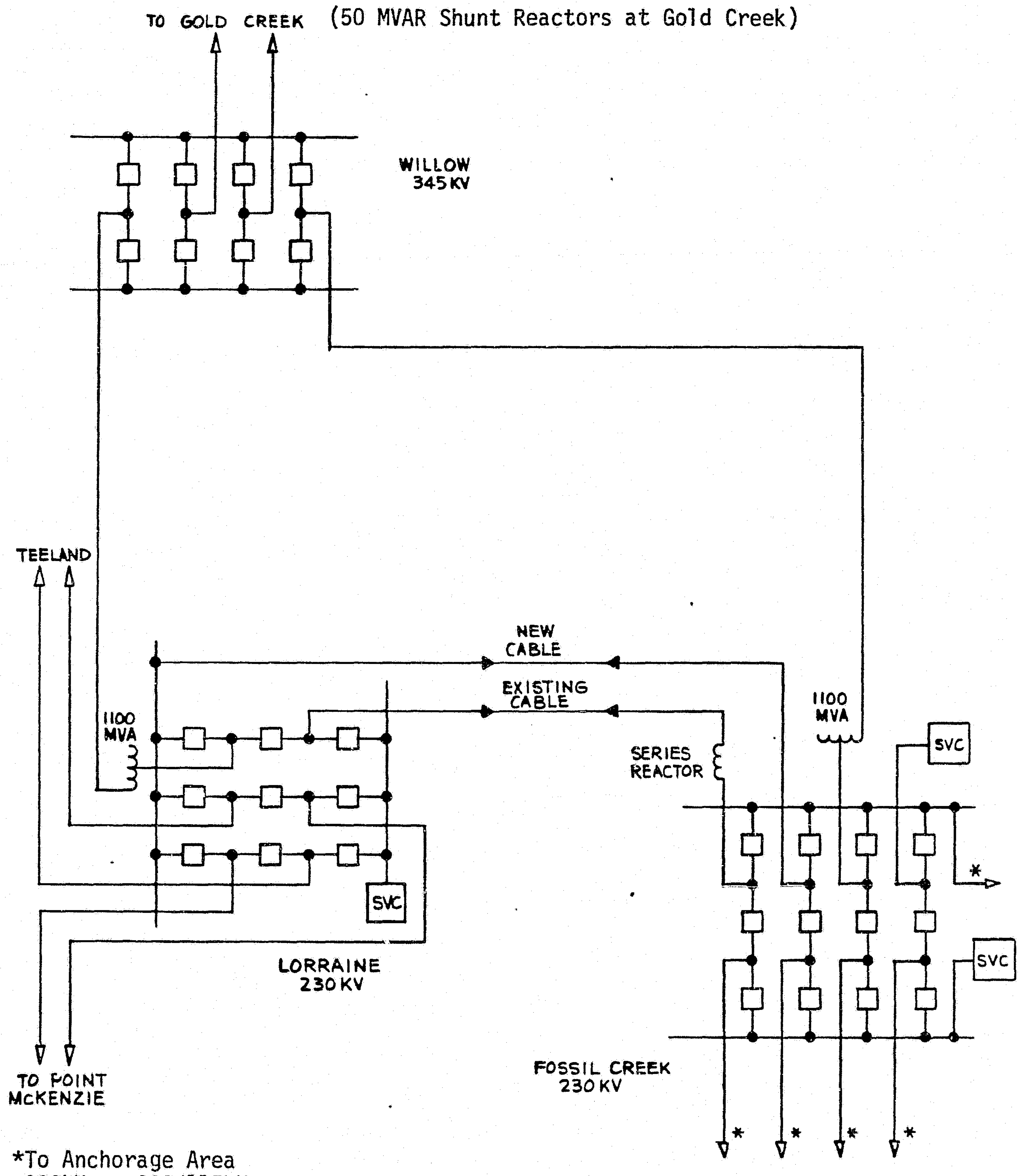
ULTIMATE
ANCHORAGE AREA
SWITCHING DIAGPAM
(PLAN S)

ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

FIGURE 4.7

HARZA-EBASCO



*To Anchorage Area
230kV or 230/115kV

ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

FIGURE 4.8

HARZA-EBASCO

ULTIMATE
ANCHORAGE AREA
SWITCHING DIAGRAM
(PLAN Q)

Such development sequences essentially reverse the timing of some of the alternatives already described. They are both economically and technically unattractive. Their present-worth costs are considered unfavorable, because they require initial (1993) installation of a 345 kV cable and only defer a lower cost development of a 345/230 kV station. This is an unfavorable trade off.

These other alternatives are also technically unfavorable because the Teeland area load would initially be supplied from Anchorage, possibly from the downtown 138 kV system during a 230 kV cable outage, which in turn, would advance the need for urban area reinforcement. Without 345/230 kV reinforcement west of Knik Arm, these alternatives also would leave the Beluga Plant with one less 230 kV tie to the Susitna system, creating a potential transient stability problem. These problems have led to rejection of those alternatives which develop all 345 kV first steps for the integration of the Susitna Project.

A few other alternatives would end up with 345 kV switching at the more centrally located Willow location. They could potentially reduce static compensation requirements. Such alternatives would have 345/230 kV transformation at W/T or Willow, rather than Lorraine. In general they require higher development costs and return their uncertain benefits late in the development sequence.

One version, for instance, would develop 345/230 kV transformation at both W/T and Lorraine; another would modify Plan Y by locating the 345/230 kV transformation at Willow and extend the 230 kV circuit to Teeland. In this latter example, the additional 230 kV would result in higher losses, less favorable performance when it must operate in parallel with the 345 kV cable, and higher initial costs. An alternative augmentation of Plan Y by an additional 345 kV switching station midway between W/T and Gold Creek late in its development sequence is judged to be able to provide greater improvement at a similar present worth cost.

In general, attempts of this nature to relocate switching from W/T or to otherwise modify previously described plans have not been found to be favorable. It is therefore concluded that the previously-outlined alternatives offer optimums of cost and performance for development of the Susitna-Anchorage transmission system.

4763B

STATIC VAR COMPENSATION

5 SIZING THE STATIC VAR COMPENSATION (SVC)

At this point, only load flow studies have been performed; these are inadequate by themselves to fully define SVC requirements. They do establish lower limits for the required dynamic ranges and allow an estimate of transient requirements to be made.

It is important to distinguish between the total range of the SVC and its dynamic range. The former is usually much larger than the latter because of the addition of mechanically switched capacitors or shunt reactors to bias the MVAR operating point of the dynamic portion of the SVC. These mechanically switched devices can be used to follow slowly changing reactive power demands of loads, while holding most of the dynamic range in reserve.

The dynamic range is of the greatest significance in planning because the unit price of the dynamic portion may be ten times that of the mechanically switched portion. For this reason the changes in SVC output which occur as a result of line outages are more significant than the absolute output of the SVCs at any particular time.

The load flow cases show changes in the steady state outputs of the SVCs for various critical cases. This is one part of the dynamic range requirement of each SVC. The other part of the dynamic range requirement is that associated with transient power transfers during recovery from the fault causing the loss of a system element. The latter component depends upon the transient characteristics of the loads and generators and upon the extent to which transient voltages can be allowed to drop without risking instability. Only transient stability studies can evaluate these requirements accurately.

One can make a rather crude estimate of the required SVC dynamic ranges by applying a multiplying factor to the range required to cope with changes from one steady state condition to another. A reasonable factor might be to add 50% to the range needed for the load flow outage.

If one applies such a factor to the load flow results show in Appendix C, it is possible to obtain an estimate of the dynamic ranges required by the SVCs of the preferred plan.

In the Fairbanks area the SVC requirements increase between 1993 and 2015. However, the change is moderated by the elimination of one possible contingency (a critical Healy 230-kV breaker failure) in the intervening period. In 1993 the worst case (A6) requires a 30 MVAR change at Ester. In 2005 the worst case (B6) requires a combined change of 64 MVAR at Ester and Healy. If these changes are increased by 50%, one can estimate that roughly 45 and 96 MVAR are the dynamic ranges which must be available at the time of peak loads in those periods.

In order to allow the SVCs to do routine voltage regulation also, these ranges must be extended by the amount of the dynamic range which might be utilized for that purpose. If that requirement on the order of ±25 MVAR (enough to cope with ±25 MVAR changes), an additional 50 MVAR of dynamic range would be required. This would increase the required dynamic ranges to 95 and 146 MVAR in 1993 and 2015, respectively. Considering that the SVCs already planned for stations in the Healy-Fairbanks area have some available dynamic range, two SVCs, each having about 60-70 MVAR dynamic ranges, seem to be adequate.

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For Anchorage the worst outage case (A2) in 1993 requires SVC changes of 118 MVAR. By 2015 this increases to 172 MVAR in case B3. Adding 50% increases these to 177 and 258 MVAR, respectively. Taking a larger regulating range of ±50 MVAR for this larger and more diverse area would increase the dynamic range requirements to 277 and 358 MVAR in the two time periods. For estimating purposes it may be assumed that two SVCs, each with a 140 MVAR dynamic range, are initially adequate at Fossil Creek. A third unit of 140 MVAR range at W/T would appear to be a reasonable addition later.

It should be emphasized that these are just rough estimates, subject to transient stability studies. Also, there has been no allowance for the simultaneous outage of an SVC and another critical element. If such redundancy is desired, sizes must be larger. Furthermore, an estimate of the total ranges for these SVC's has not been made, since that is dependent upon net load power factors, which have not been estimated for this report.

4763B

GEOMAGNETIC INDUCED CURRENTS

In the case of series capacitors, the lowest MVAR would be required if they are inserted at the 345-kV level at Gold Creek where phase currents are lowest. It is uncertain whether the cost would be lowest, because of the higher voltage to ground at that point. If two-winding transformers are used, they could be either at the 345/230-kV interfaces or at the 230/138-kV interfaces. Cost would be a major influence, although any potential for expansion of 230 kV in the Healy-Fairbanks area, like generation additions, would be handicapped by the latter choice.

The major drawback to the use of two winding transformers is that their impedances would increase and adversely affect performance. The biggest problems with series capacitors are their relatively low reliability and high maintenance requirements. This choice between the two approaches needs further study.

APPENDIX

A
B
C

APPENDIX A

RAILBELT AREA LOAD FORECAST
1983-2020

APPENDIX A

Railbelt Area Load and Reserve Capacity Forecast (1983-2020)

	PEAK LOAD					ADDED GENERATION			RETIRED GENERA		TOTAL CAPACITY				PEAK RESERVE CAPACITY						
	SOUTH		NORTH		SYSTEM	SOUTH	NORTH	SUSITNA	SOUTH	NORTH	SOUTH	NORTH	SUSITNA	SYSTE	SOUTH		NORTH		SYSTEM		
YEAR	(MW)	(%)	(MW)	(%)	(MW)	(MW)	(MW)		(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(%)	(MW)	(%)	(MW)	(%)	YEAR
1983	469.00	81.00	110.00	19.00	579.00						813.80	308.70	.00	1122.50	344.80	73.52	198.70	180.64	543.50	93.87	1983
1984	493.00	80.95	116.00	19.05	609.00						813.80	308.70	.00	1122.50	320.80	65.07	192.70	166.12	513.50	84.32	1984
1985	517.00	80.91	122.00	19.09	639.00						813.80	308.70	.00	1122.50	296.80	57.41	186.70	153.03	483.50	75.67	1985
1986	538.00	80.66	129.00	19.34	667.00						813.80	308.70	.00	1122.50	275.80	51.26	179.70	139.30	455.50	68.29	1986
1987	558.00	80.40	136.00	19.60	694.00					4.00	813.80	304.70	.00	1118.50	255.80	45.84	168.70	124.04	424.50	61.17	1987
1988	579.00	80.08	144.00	19.92	723.00	97.00					910.80	304.70	.00	1215.50	331.80	57.31	160.70	111.60	492.50	68.12	1988
1969	599.00	79.87	151.00	20.13	750.00					5.00	910.80	299.70	.00	1210.50	311.80	52.05	148.70	98.48	460.50	61.40	1989
1990	619.00	79.67	158.00	20.33	777.00						910.80	299.70	.00	1210.50	291.80	47.14	141.70	89.68	433.50	55.79	1990
1991	633.00	79.52	163.00	20.48	796.00					18.40	910.80	281.30	.00	1192.10	277.80	43.89	118.30	72.58	396.10	49.76	1991
1992	646.00	79.36	168.00	20.64	814.00				16.30	17.40	894.50	263.90	.00	1158.40	248.50	38.47	95.90	57.00	344.40	42.31	1992
1993	659.00	79.21	173.00	20.79	[illegible]			825.00	8.60	7.00	885.90	256.90	825.00	1967.80	226.90	34.43	83.90	48.50	1135.80	136.51	1993
1994	672.00	79.06	178.00	20.94	850.00				30.90		855.00	256.90	825.00	1936.90	183.00	27.23	78.90	44.33	1086.90	127.87	1994
1995	686.00	78.94	183.00	21.06	869.00				19.50	28.00	835.50	228.90	825.00	1889.40	149.50	21.79	45.90	25.08	1020.40	117.42	1995
1996	697.00	78.94	186.00	21.06	883.00					65.00	835.50	163.90	825.00	1824.40	138.50	19.87	-22.10	-11.88	941.40	106.61	1996
1997	709.00	78.87	190.00	21.13	899.00				.90	93.70	834.60	70.20	825.00	1729.80	125.60	17.72	-119.80	-63.05	830.80	92.41	1997
1998	721.00	78.80	194.00	21.20	915.00				50.20	5.60	784.40	64.60	825.00	1674.00	63.40	8.79	-129.40	-66.70	759.00	82.95	1998
1999	732.00	78.79	197.00	21.21	929.00						784.40	64.60	825.00	1674.00	52.40	7.16	-132.40	-67.21	745.00	80.19	1999
2000	744.00	78.73	201.00	21.27	945.00				18.60		765.80	64.60	825.00	1655.40	21.80	2.93	-136.40	-67.86	710.40	75.17	2000
2001	762.00	78.72	206.00	21.28	968.00				.20		765.60	64.60	825.00	1655.20	3.60	.47	-141.40	-68.64	687.20	70.99	2001
2002	780.00	78.71	211.00	21.29	991.00			600.00	50.90	25.00	714.70	39.60	1425.00	2179.30	-65.30	-8.37	-171.40	-81.23	1188.30	119.91	2002
2003	798.00	78.78	215.00	21.22	1013.00				53.00		661.70	39.60	1425.00	2126.30	-136.30	-17.08	-175.40	-81.58	1113.30	109.90	2003
2004	816.00	78.76	220.00	21.24	1036.00						661.70	39.60	1425.00	2126.30	-154.30	-18.91	-180.40	-82.00	1090.30	105.24	2004
2005	834.00	78.75	225.00	21.25	1059.00				88.00	21.00	573.70	18.60	1425.00	2017.30	-260.30	-31.21	-206.40	-91.73	958.30	90.49	2005
2006	859.00	78.81	231.00	21.19	1090.00						573.70	18.60	1425.00	2017.30	-285.30	-33.21	-212.40	-91.95	927.30	85.07	2006
2007	885.00	78.81	238.00	21.19	1123.00						573.70	18.60	1425.00	2017.30	-311.30	-35.18	-219.40	-92.18	894.30	79.63	2007
2008	910.00	78.86	244.00	21.14	1154.00				26.40		547.30	18.60	1425.00	1990.90	-362.70	-39.86	-225.40	-92.38	836.90	72.52	2008
2009	936.00	78.92	250.00	21.08	1186.00				.90		546.40	18.60	1425.00	1990.00	-389.60	-41.62	-231.40	-92.56	804.00	67.79	2009
2010	961.00	78.96	256.00	21.04	1217.00						546.40	18.60	1425.00	1990.00	-414.60	-43.14	-237.40	-92.73	773.00	63.52	2010
2011	985.00	78.93	263.00	21.07	1248.00				155.00	5.60	391.40	13.00	1425.00	1829.40	-593.60	-60.26	-250.00	-95.06	581.40	46.59	2011
2012	1010.00	78.91	270.00	21.09	1280.00				294.40		97.00	13.00	1425.00	1535.00	-913.00	-90.40	-257.00	-95.19	255.00	19.92	2012
2013	1036.00	78.90	277.00	21.10	1313.00						97.00	13.00	1425.00	1535.00	-939.00	-90.64	-264.00	-95.31	222.00	16.91	2013
2014	1062.00	78.90	284.00	21.10	1346.00						97.00	13.00	1425.00	1535.00	-965.00	-90.87	-271.00	-95.42	189.00	14.04	2014
2015	1090.00	78.93	291.00	21.07	1381.00					13.00	97.00	.00	1425.00	1522.00	-993.00	-91.10	-291.00	-100.00	141.00	10.21	2015
2016	1117.00	78.88	299.00	21.12	1416.00						97.00	.00	1425.00	1522.00	-1020.00	-91.32	-299.00	-100.00	106.00	7.49	2016
2017	1146.00	78.87	307.00	21.13	1453.00						97.00	.00	1425.00	1522.00	-1049.00	-91.54	-307.00	-100.00	69.00	4.75	2017
2018	1176.00	78.93	314.00	21.07	1490.00						97.00	.00	1425.00	1522.00	-1079.00	-91.75	-314.00	-100.00	32.00	2.15	2018
2019	1206.00	78.93	322.00	21.07	1528.00						97.00	.00	1425.00	1522.00	-1109.00	-91.96	-322.00	-100.00	-6.00	-.39	2019
2020	1236.00	78.88	331.00	21.12	1567.00						97.00	.00	1425.00	1522.00	-1139.00	-92.15	-331.00	-100.00	-45.00	-2.87	2020

APPENDIX B

RAILBELT AREA GENERATING CAPACITY FORECAST

1983-2020

APPENDIX B
Railbelt Area Generating Capacity Forecast

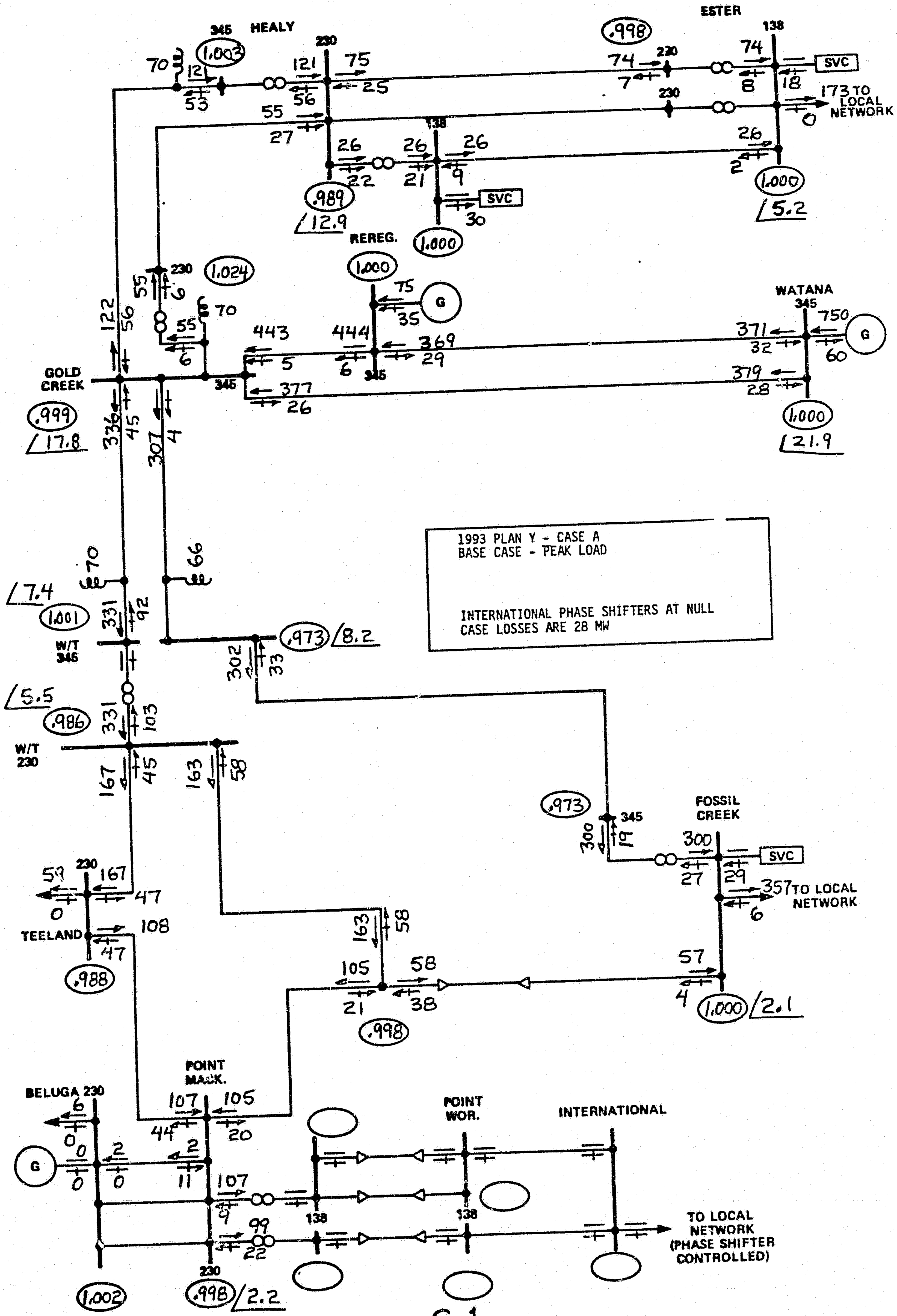
GENERATING STATION	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
UNIVERSITY OF ALASKA	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6
GOLDEN VALLEY	193.8	193.8	193.8	193.8	193.8	193.8	193.8	193.8	175.4	158	158	158	130	65	0	0	0	0	0
FAIRBANKS MUNICIPAL	68.5	68.5	68.5	68.5	64.5	64.5	59.5	59.5	59.5	59.5	52.5	52.5	52.5	52.5	26.6	21	21	21	21
TOTAL FAIRBANKS AREA	280.9	280.9	280.9	280.9	276.9	276.9	271.9	271.9	253.5	236.1	229.1	229.1	201.1	136.1	45.2	39.6	39.6	39.6	39.6
HEALEY	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	25	25	25	25	25
TOTAL NORTHERN AREA	308.7	308.7	308.7	308.7	304.7	304.7	299.7	299.7	281.3	263.9	256.9	256.9	228.9	163.9	70.2	64.6	64.6	64.6	64.6
SUSITNA	0	0	0	0	0	0	0	0	0	0	825	825	825	825	825	825	825	825	825
MATANUSKA	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	0	0	0	0	0
BELUGA	321.2	321.2	321.2	321.2	321.2	321.2	321.2	321.2	321.2	321.2	321.2	321.2	321.2	321.2	321.2	289	289	289	289
EKLUTNA	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
INTERNATIONAL	46	46	46	46	46	46	46	46	46	46	46	32	18	18	18	18	18	0	0
ANCHORAGE MUNICIPAL	311.6	311.6	311.6	311.6	311.6	311.6	311.6	311.6	311.6	295.3	295.3	279	279	279	279	261	261	261	261
TOTAL ANCHORAGE AREA	357.6	357.6	357.6	357.6	357.6	357.6	357.6	357.6	357.6	341.3	341.3	311	297	297	297	279	279	261	261
SEWARD	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	0	0	0	0	0	0	0
COOPER, GRANT, BRADLEY	16	16	16	16	16	113	113	113	113	113	113	113	113	113	113	113	113	113	113
BERNICE LAKE	80.3	80.3	80.3	80.3	80.3	80.3	80.3	80.3	80.3	80.3	71.7	71.7	71.7	71.7	71.7	71.7	71.7	71.7	71.7
HOMER	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	1.7	1.7	1.7	1.7	1.7	1.7	1.1	.9
TOTAL KENAI PENINSULA	104.1	104.1	104.1	104.1	104.1	201.1	201.1	201.1	201.1	201.1	192.5	191.9	186.4	186.4	186.4	186.4	186.4	185.8	185.6
TOTAL SOUTHERN AREA	813.8	813.8	813.8	813.8	813.8	910.8	910.8	910.8	910.8	894.5	885.9	855	835.5	835.5	834.6	784.4	784.4	765.8	765.6
SYSTEM TOTAL	1122.5	1122.5	1122.5	1122.5	1118.5	1215.5	1210.5	1210.5	1192.1	1158.4	1967.8	1936.9	1889.4	1824.4	1729.8	1674	1674	1655.4	1655.2

Railbelt Area Generating Capacity Forecast

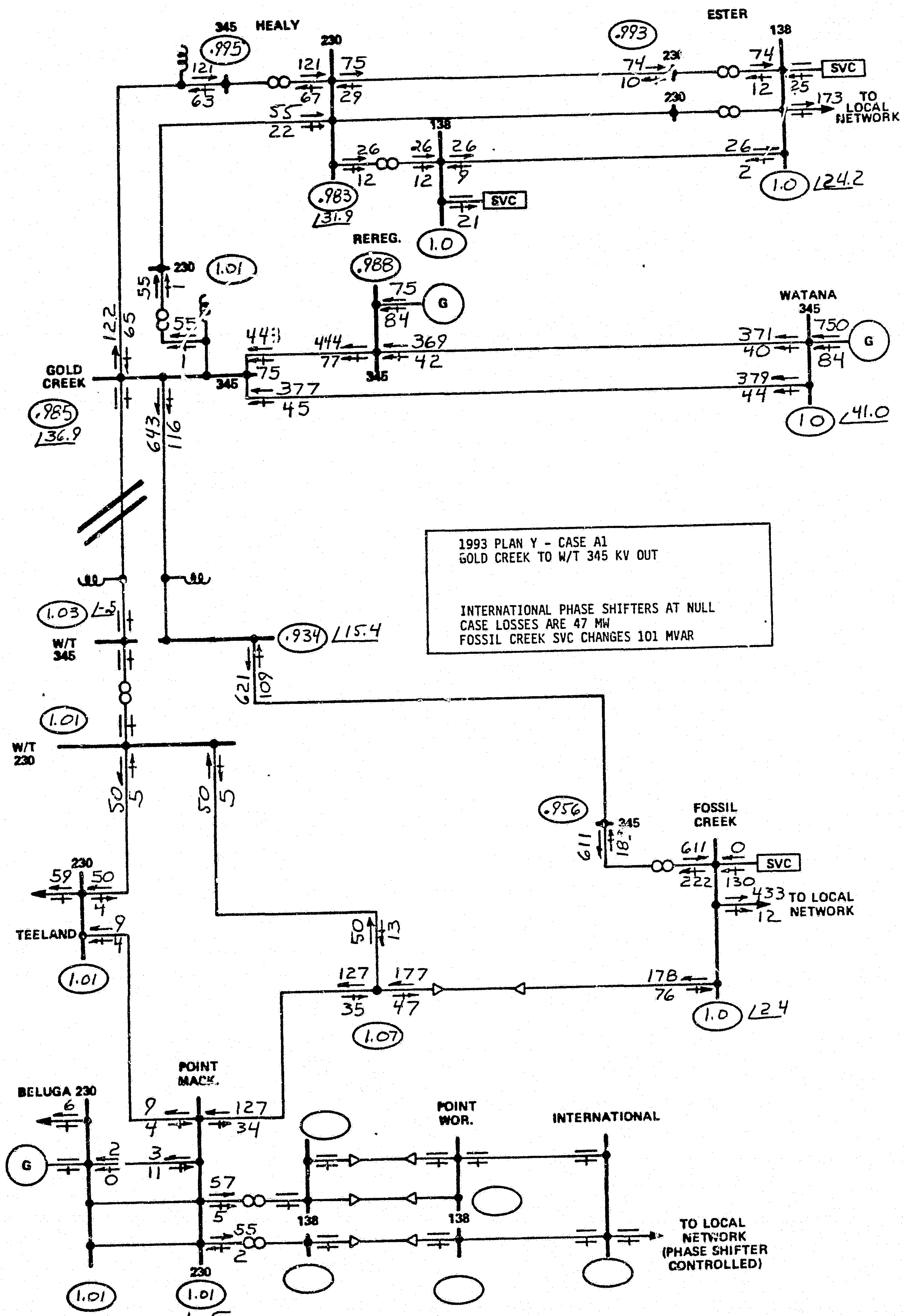
GENERATING STATION	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
UNIVERSITY OF ALASKA	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	13	13	13	13	0	0	0	0	0	0
GOLDEN VALLEY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FAIRBANKS MUNICIPAL	21	21	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL FAIRBANKS AREA	39.6	39.6	39.6	18.6	18.6	18.6	18.6	18.6	18.6	13	13	13	13	0	0	0	0	0	0
HEALEY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL NORTHERN AREA	39.6	39.6	39.6	18.6	18.6	18.6	18.6	18.6	18.6	13	13	13	13	0	0	0	0	0	0
SUSITNA	1425	1425	1425	1425	1425	1425	1425	1425	1425	1425	1425	1425	1425	1425	1425	1425	1425	1425	1425
MATANUSKA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BELUGA	289	236	236	178	178	178	178	178	178	178	0	0	0	0	0	0	0	0	0
EKLUTNA	30	30	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INTERNATIONAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANCHORAGE MUNICIPAL	229	229	229	229	229	229	229	229	229	90	0	0	0	0	0	0	0	0	0
TOTAL ANCHORAGE AREA	229	229	229	229	229	229	229	229	229	90	0	0	0	0	0	0	0	0	0
SEWARD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COOPER, GRANT, BRADLEY	113	113	113	113	113	113	113	113	113	97	97	97	97	97	97	97	97	97	97
BERNICE LAKE	52.8	52.8	52.8	52.8	52.8	52.8	26.4	26.4	26.4	26.4	0	0	0	0	0	0	0	0	0
HOMER	.9	.9	.9	.9	.9	.9	.9	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL KENAI PENINSULA	166.7	166.7	166.7	166.7	166.7	166.7	140.3	139.4	139.4	123.4	97	97	97	97	97	97	97	97	97
TOTAL SOUTHERN AREA	714.7	661.7	661.7	573.7	573.7	573.7	547.3	546.4	546.4	391.4	97	97	97	97	97	97	97	97	97
SYSTEM TOTAL	2179.3	2126.3	2126.3	2017.3	2017.3	2017.3	1990.9	1990	1990	1829.4	1535	1535	1535	1522	1522	1522	1522	1522	1522

APPENDIX C

LOAD FLOW DIAGRAMS

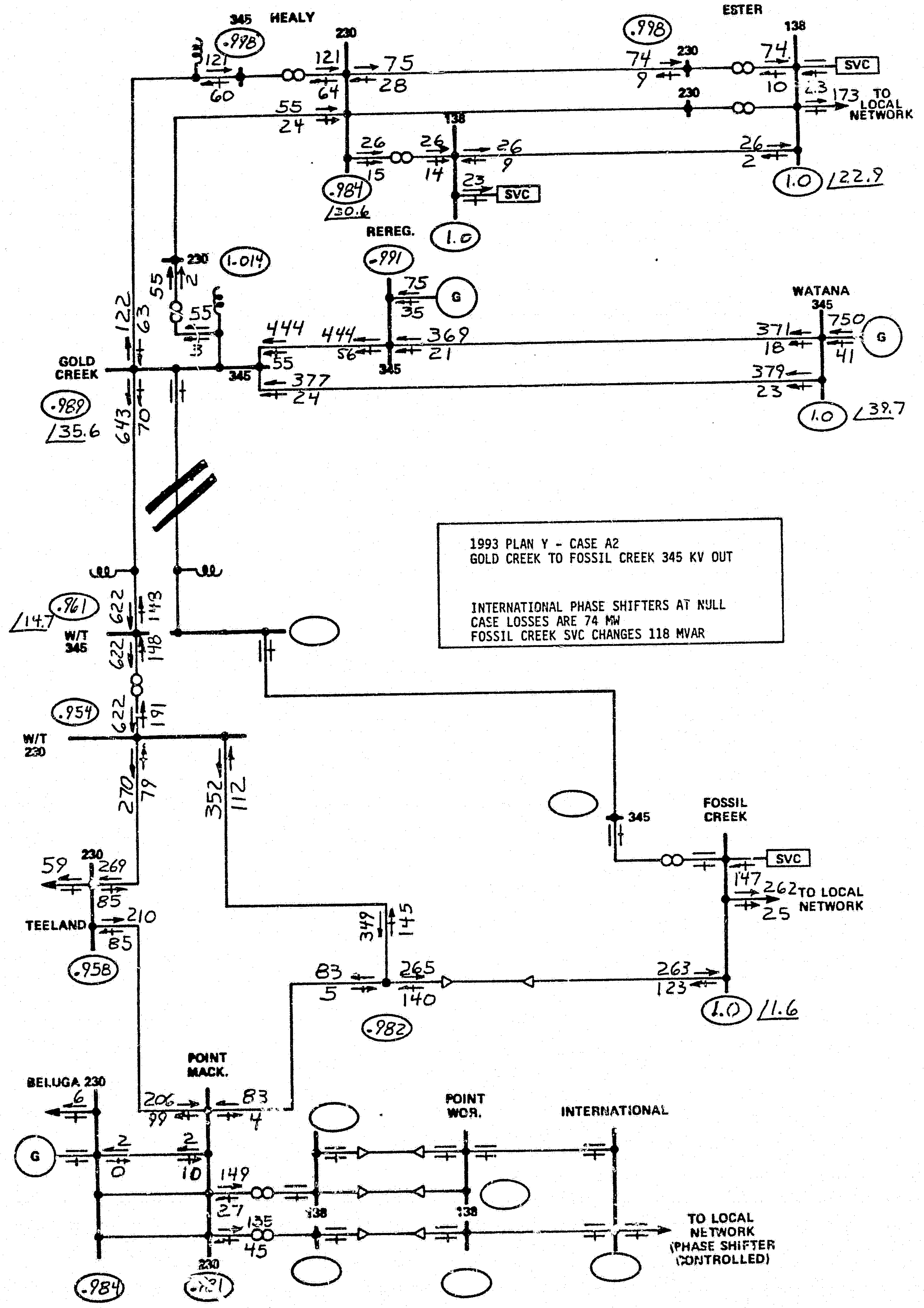

HEALY
ESTER
SVC
173 TO LOCAL NETWORK
REREG.
WATANA
GOLD CREEK
W/T 345
W/T 230
TEELAND
FOSSIL CREEK
357 TO LOCAL NETWORK
POINT MACK.
BELUGA 230
POINT WOR.
INTERNATIONAL
TO LOCAL NETWORK (PHASE SHIFTER CONTROLLED)
1993 PLAN Y - CASE A
BASE CASE - PEAK LOAD
INTERNATIONAL PHASE SHIFTERS AT NULL
CASE LOSSES ARE 28 MW

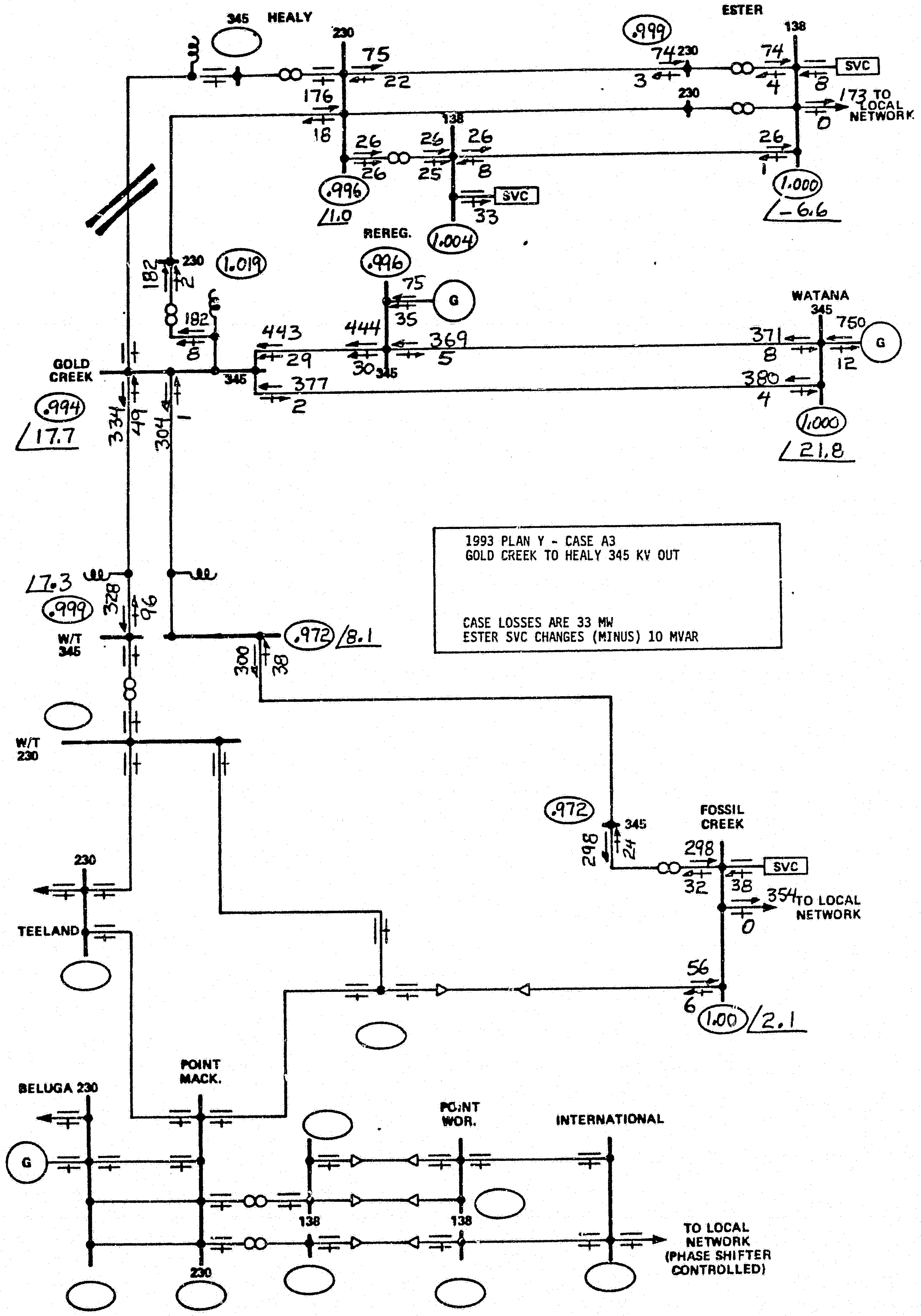
C 1



1993 PLAN Y - CASE A1
GOLD CREEK TO W/T 345 KV OUT
INTERNATIONAL PHASE SHIFTERS AT NULL
CASE LOSSES ARE 47 MW
FOSSIL CREEK SVC CHANGES 101 MVAR
HEALY
345
230
138
ESTER
SVC
TO LOCAL NETWORK
REREG.
G
WATANA
345
GOLD CREEK
W/T 345
W/T 230
TEELAND
FOSSIL CREEK
TO LOCAL NETWORK
BELUGA 230
POINT MACK.
POINT WOR.
INTERNATIONAL
TO LOCAL NETWORK (PHASE SHIFTER CONTROLLED)

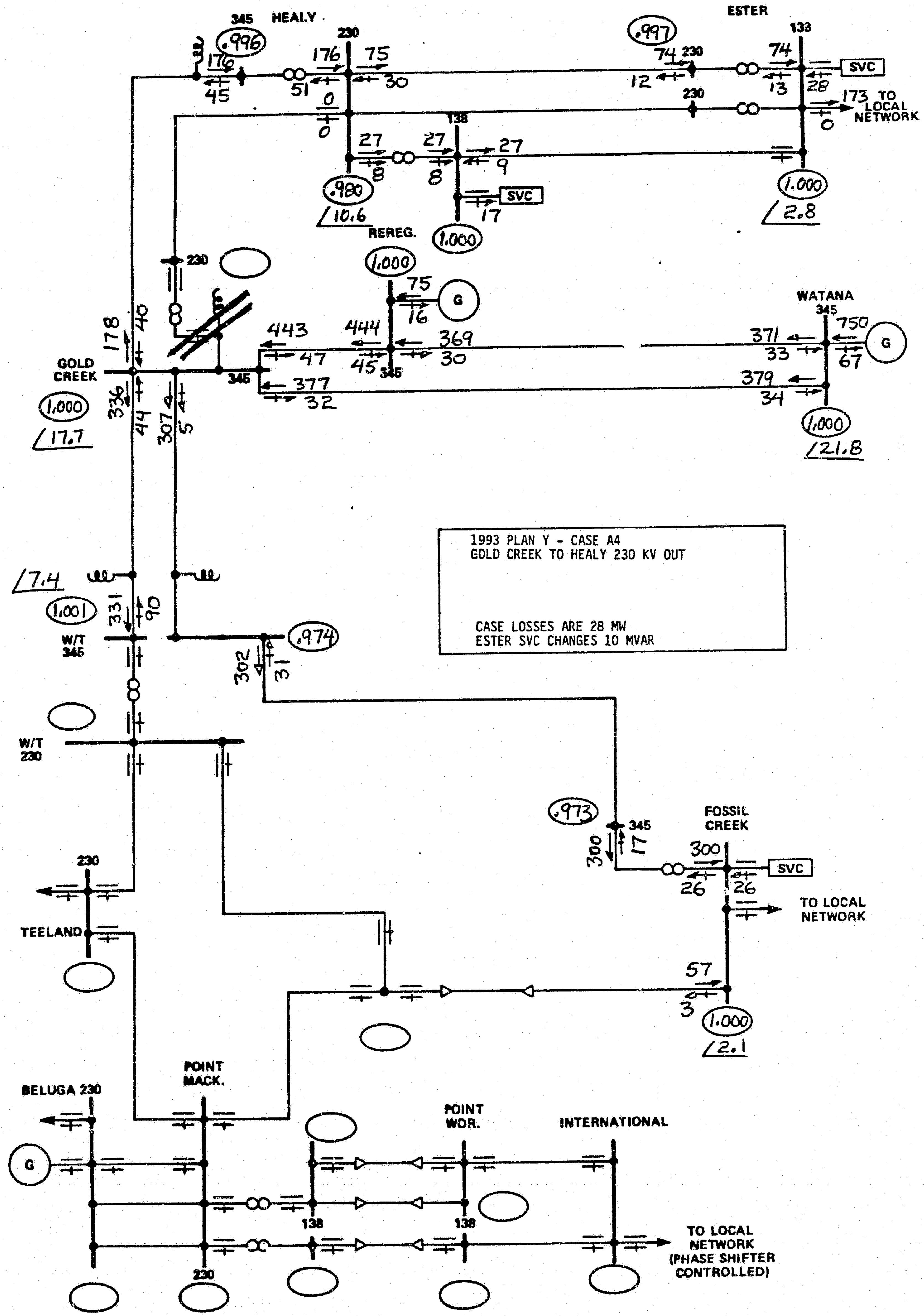
C2


HEALY
ESTER
TO LOCAL NETWORK
SVC
REREG.
WATANA
GOLD CREEK
W/T 345
W/T 230
TEELAND
FOSSIL CREEK
TO LOCAL NETWORK
BELUGA 230
POINT MACK.
POINT WOR.
INTERNATIONAL
TO LOCAL NETWORK (PHASE SHIFTER CONTROLLED)
1993 PLAN Y - CASE A2
GOLD CREEK TO FOSSIL CREEK 345 KV OUT
INTERNATIONAL PHASE SHIFTERS AT NULL
CASE LOSSES ARE 74 MW
FOSSIL CREEK SVC CHANGES 118 MVAR

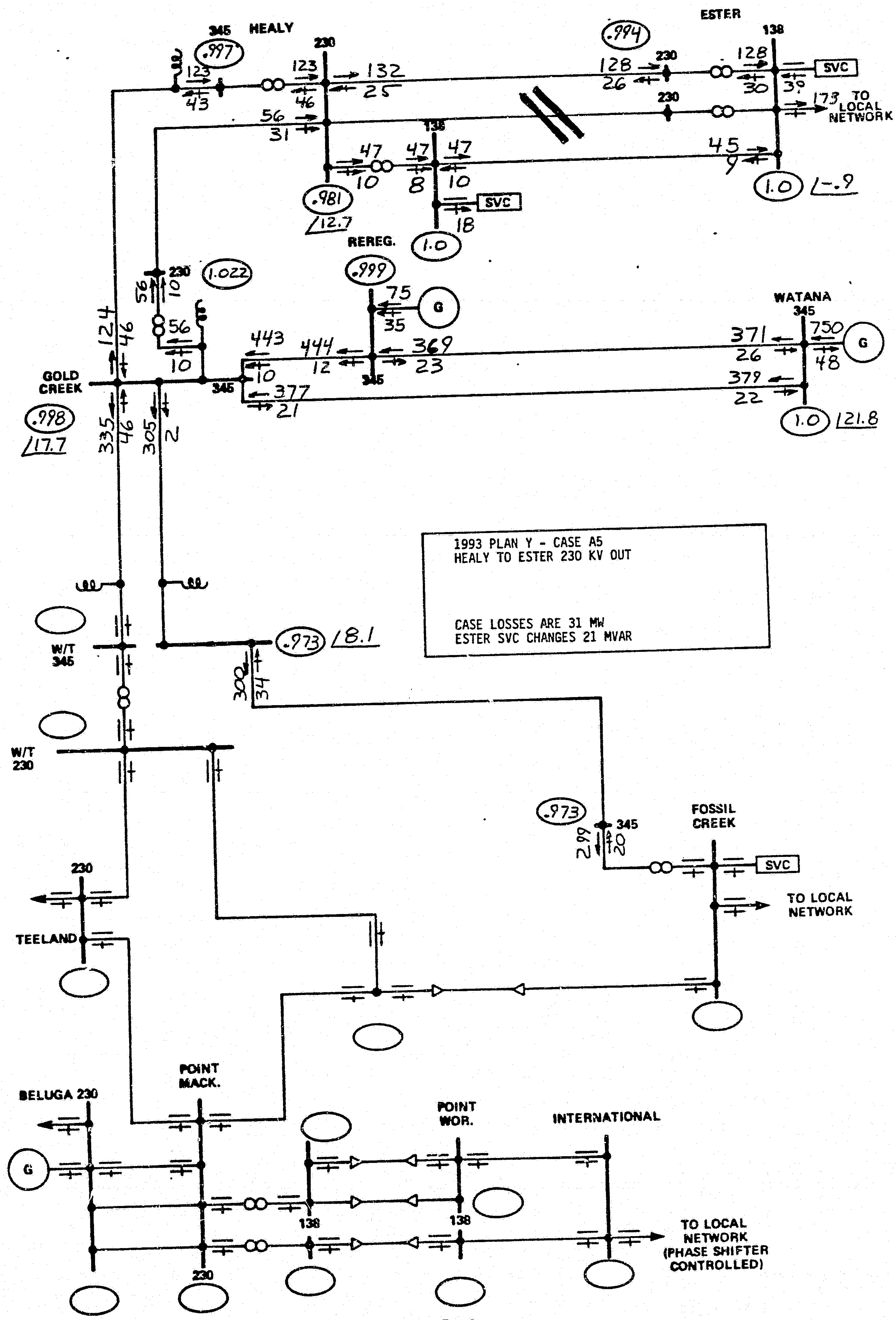


1993 PLAN Y - CASE A3
GOLD CREEK TO HEALY 345 KV OUT

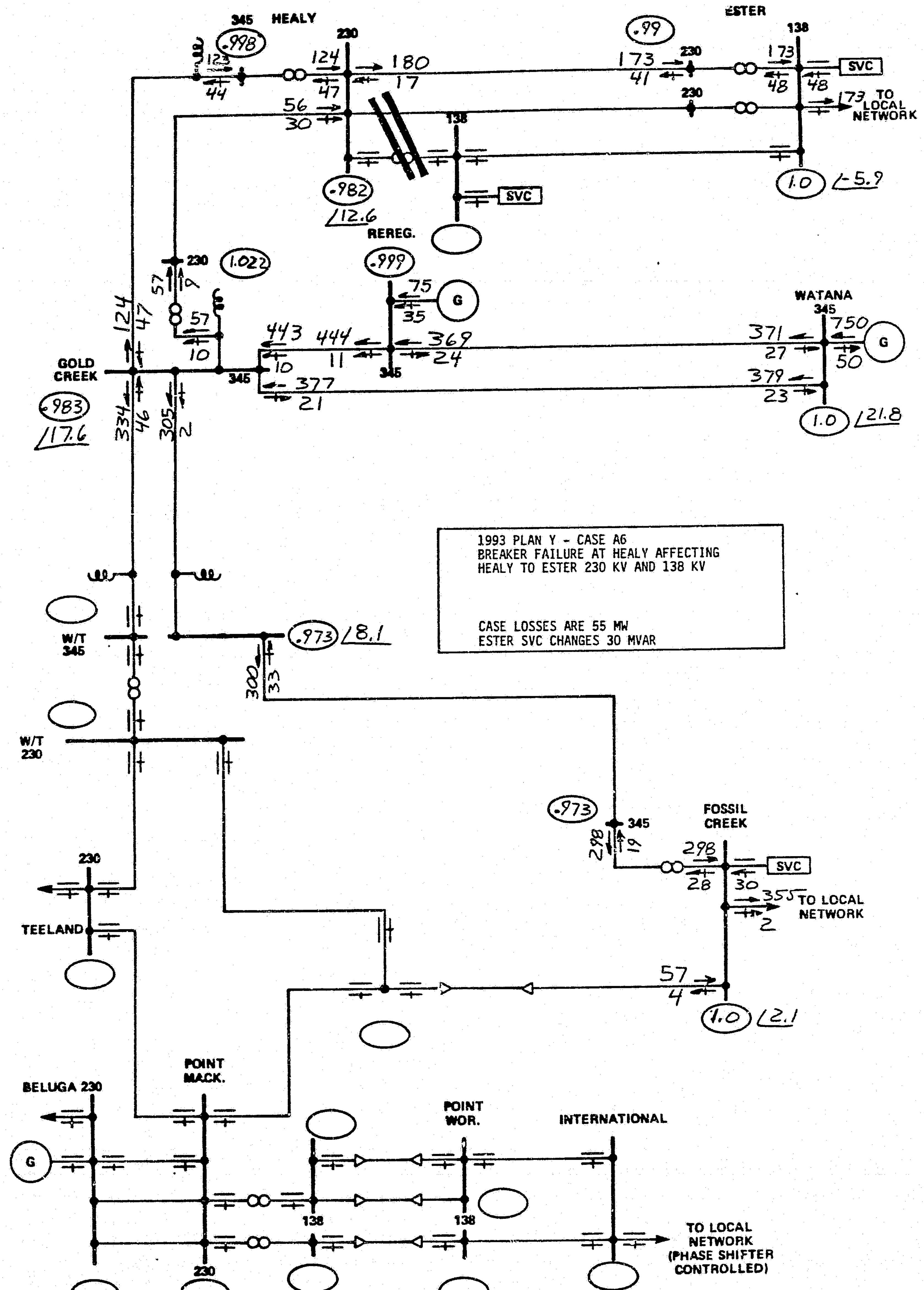
CASE LOSSES ARE 33 MW
ESTER SVC CHANGES (MINUS) 10 MVAR

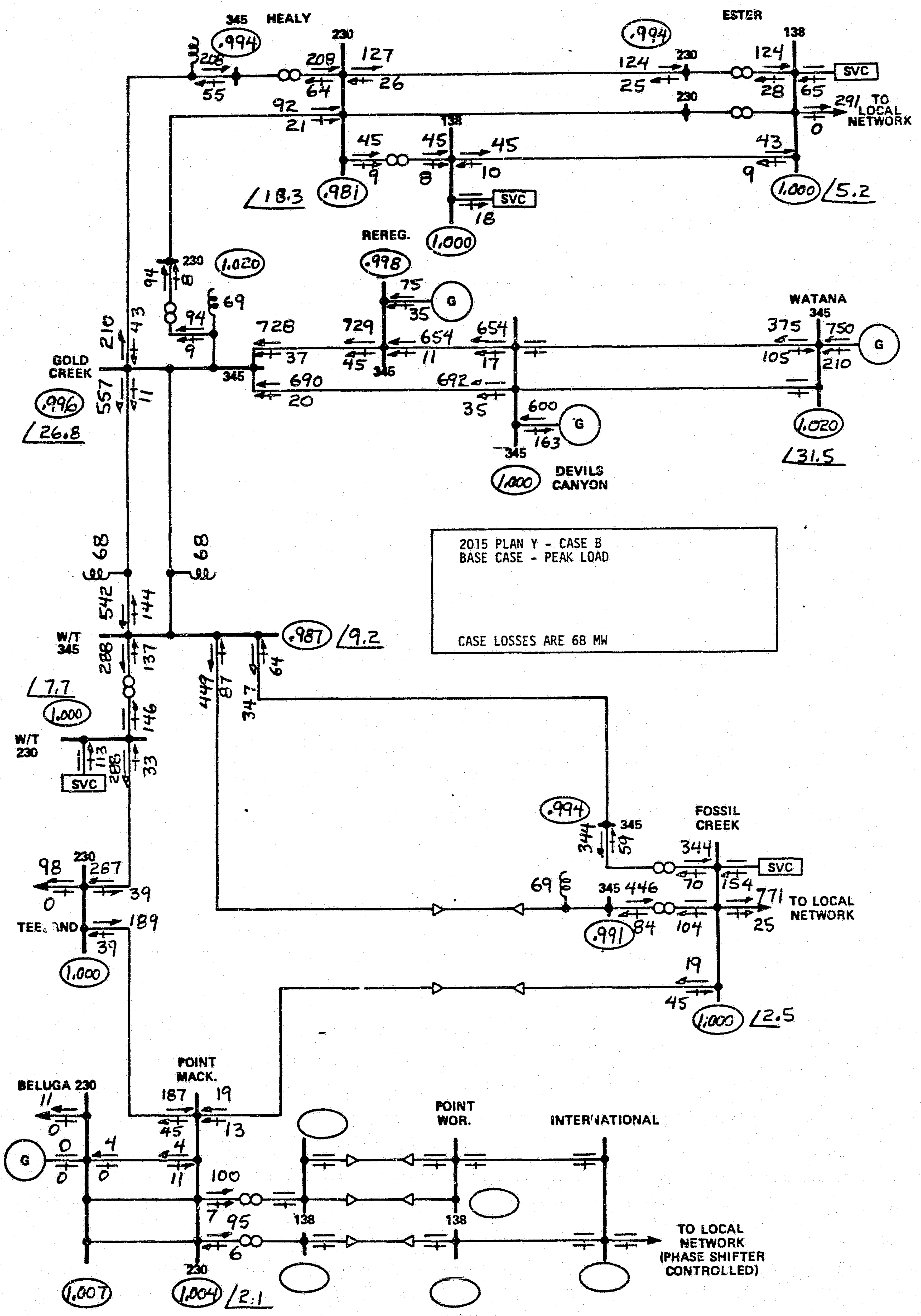

HEALY
345
230
138
ESTER
SVC
TO LOCAL NETWORK
REREG.
G
WATANA
345
GOLD CREEK
345
W/T 345
W/T 230
FOSSIL CREEK
TO LOCAL NETWORK
TEELAND
POINT MACK.
BELUGA 230
POINT WOR.
INTERNATIONAL
TO LOCAL NETWORK (PHASE SHIFTER CONTROLLED)
1993 PLAN Y - CASE A4
GOLD CREEK TO HEALY 230 KV OUT
CASE LOSSES ARE 28 MW
ESTER SVC CHANGES 10 MVAR

C5

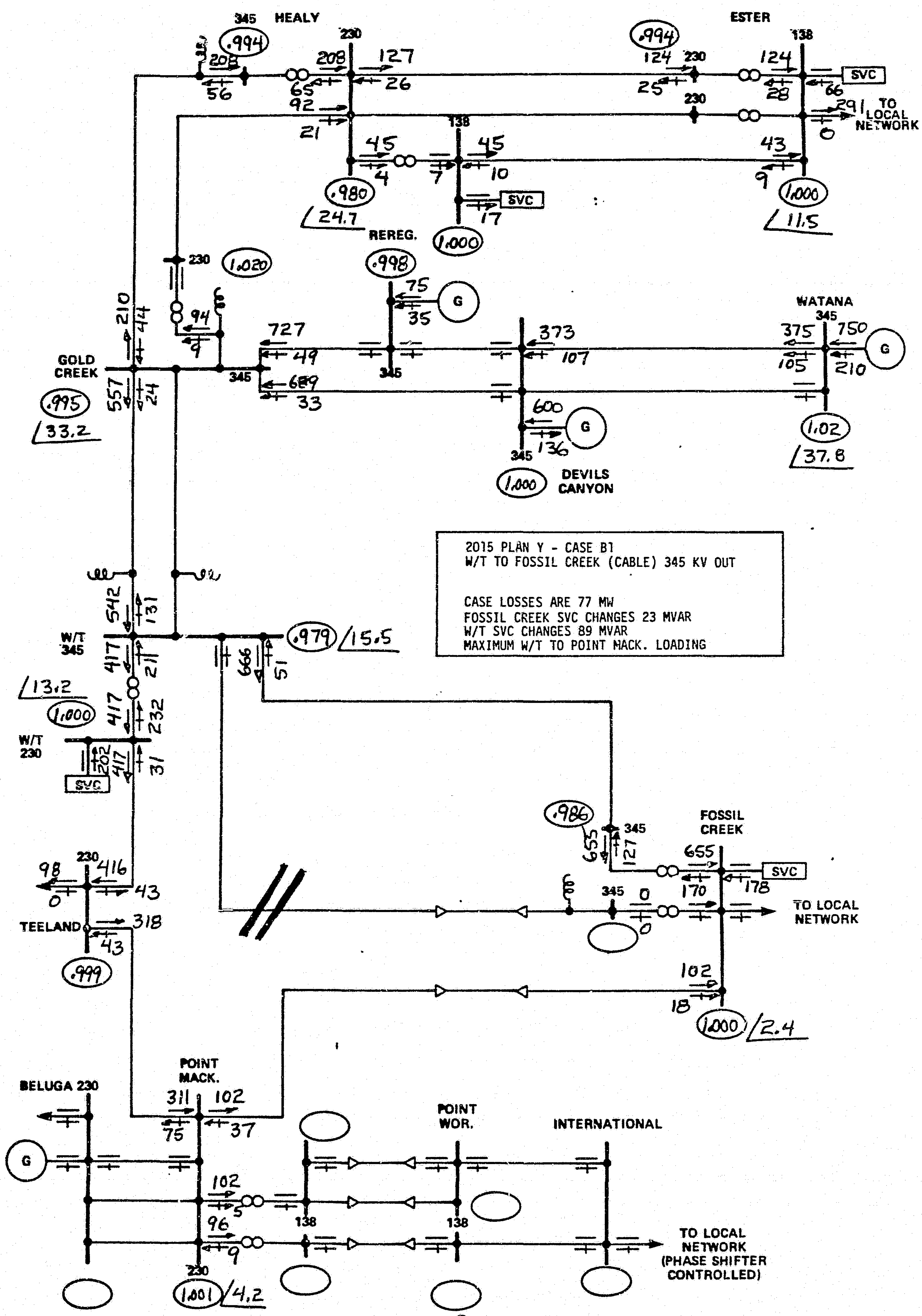

HEALY
345
230
ESTER
138
230
SVC
TO LOCAL NETWORK
138
SVC
REREG.
GOLD CREEK
345
WATANA
345
G
G
1993 PLAN Y - CASE A5
HEALY TO ESTER 230 KV OUT
CASE LOSSES ARE 31 MW
ESTER SVC CHANGES 21 MVAR
W/T
345
W/T
230
345
FOSSIL CREEK
SVC
TO LOCAL NETWORK
230
TEELAND
POINT MACK.
BELUGA 230
G
POINT WOR.
INTERNATIONAL
138
138
230
TO LOCAL NETWORK (PHASE SHIFTER CONTROLLED)

C6


1993 PLAN Y - CASE A6
BREAKER FAILURE AT HEALY AFFECTING
HEALY TO ESTER 230 KV AND 138 KV
CASE LOSSES ARE 55 MW
ESTER SVC CHANGES 30 MVAR
HEALY
ESTER
REREG.
WATANA
GOLD CREEK
W/T 345
W/T 230
FOSSIL CREEK
TEELAND
BELUGA 230
POINT MACK.
POINT WOR.
INTERNATIONAL
SVC
TO LOCAL NETWORK
TO LOCAL NETWORK (PHASE SHIFTER CONTROLLED)

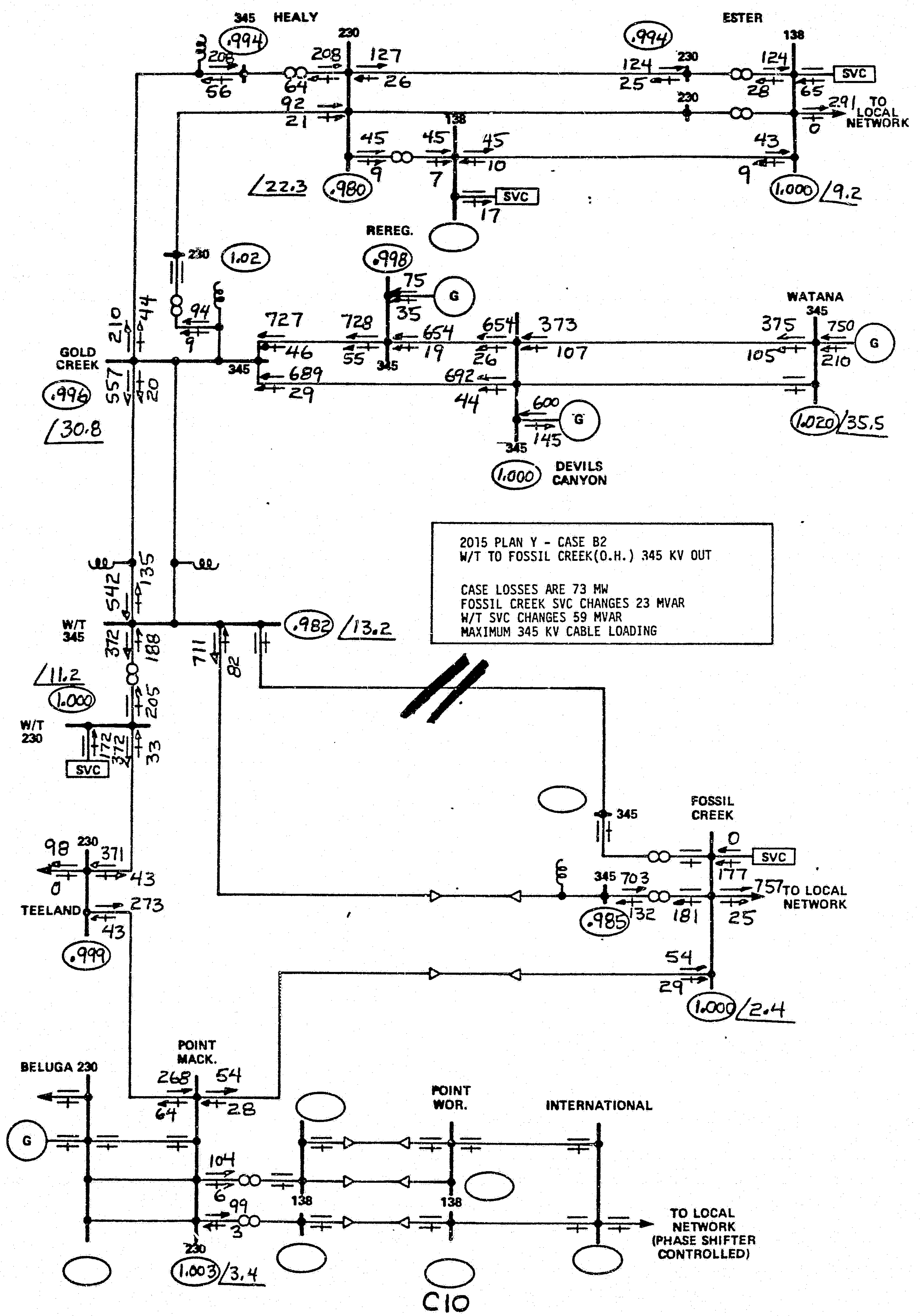

HEALY
ESTER
SVC
TO LOCAL NETWORK
REREG.
WATANA
GOLD CREEK
DEVILS CANYON
2015 PLAN Y - CASE B
BASE CASE - PEAK LOAD
CASE LOSSES ARE 68 MW
W/T 345
W/T 230
FOSSIL CREEK
TO LOCAL NETWORK
TEELAND
BELUGA 230
POINT MACK.
POINT WOR.
INTERNATIONAL
TO LOCAL NETWORK (PHASE SHIFTER CONTROLLED)

C8


HEALY
ESTER
SVC
TO LOCAL NETWORK
REREG.
WATANA
GOLD CREEK
DEVILS CANYON
2015 PLAN Y - CASE B1
W/T TO FOSSIL CREEK (CABLE) 345 KV OUT
CASE LOSSES ARE 77 MW
FOSSIL CREEK SVC CHANGES 23 MVAR
W/T SVC CHANGES 89 MVAR
MAXIMUM W/T TO POINT MACK. LOADING
W/T 345
W/T 230
TEELAND
FOSSIL CREEK
BELUGA 230
POINT MACK.
POINT WOR.
INTERNATIONAL
TO LOCAL NETWORK (PHASE SHIFTER CONTROLLED)

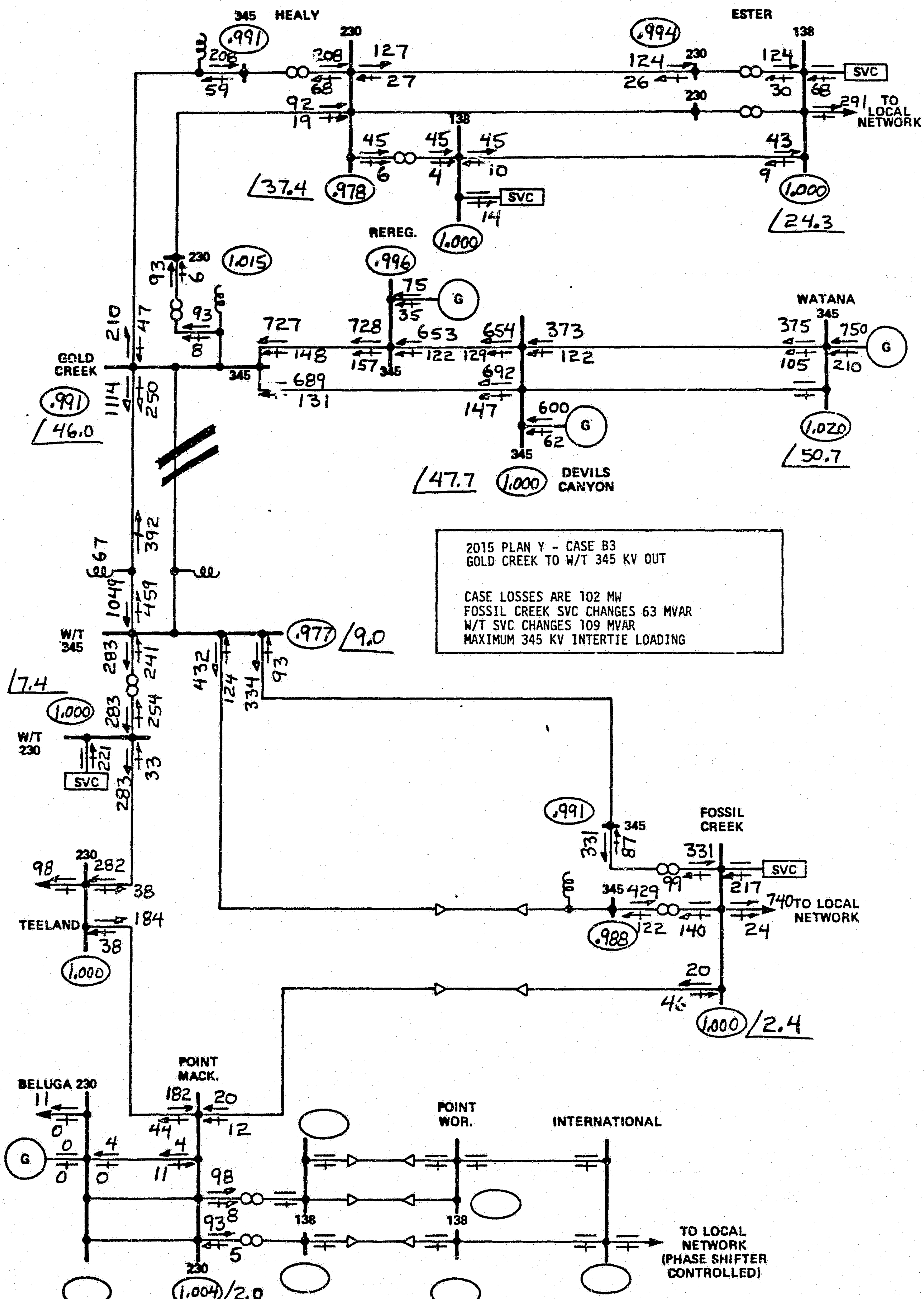
C9

8.5


HEALY
ESTER
SVC
TO LOCAL NETWORK
REREG.
WATANA
DEVILS CANYON
GOLD CREEK
W/T 345
W/T 230
TEELAND
FOSSIL CREEK
TO LOCAL NETWORK
BELUGA 230
POINT MACK.
POINT WOR.
INTERNATIONAL
TO LOCAL NETWORK (PHASE SHIFTER CONTROLLED)
2015 PLAN Y - CASE B2
W/T TO FOSSIL CREEK(O.H.) 345 KV OUT
CASE LOSSES ARE 73 MW
FOSSIL CREEK SVC CHANGES 23 MVAR
W/T SVC CHANGES 59 MVAR
MAXIMUM 345 KV CABLE LOADING

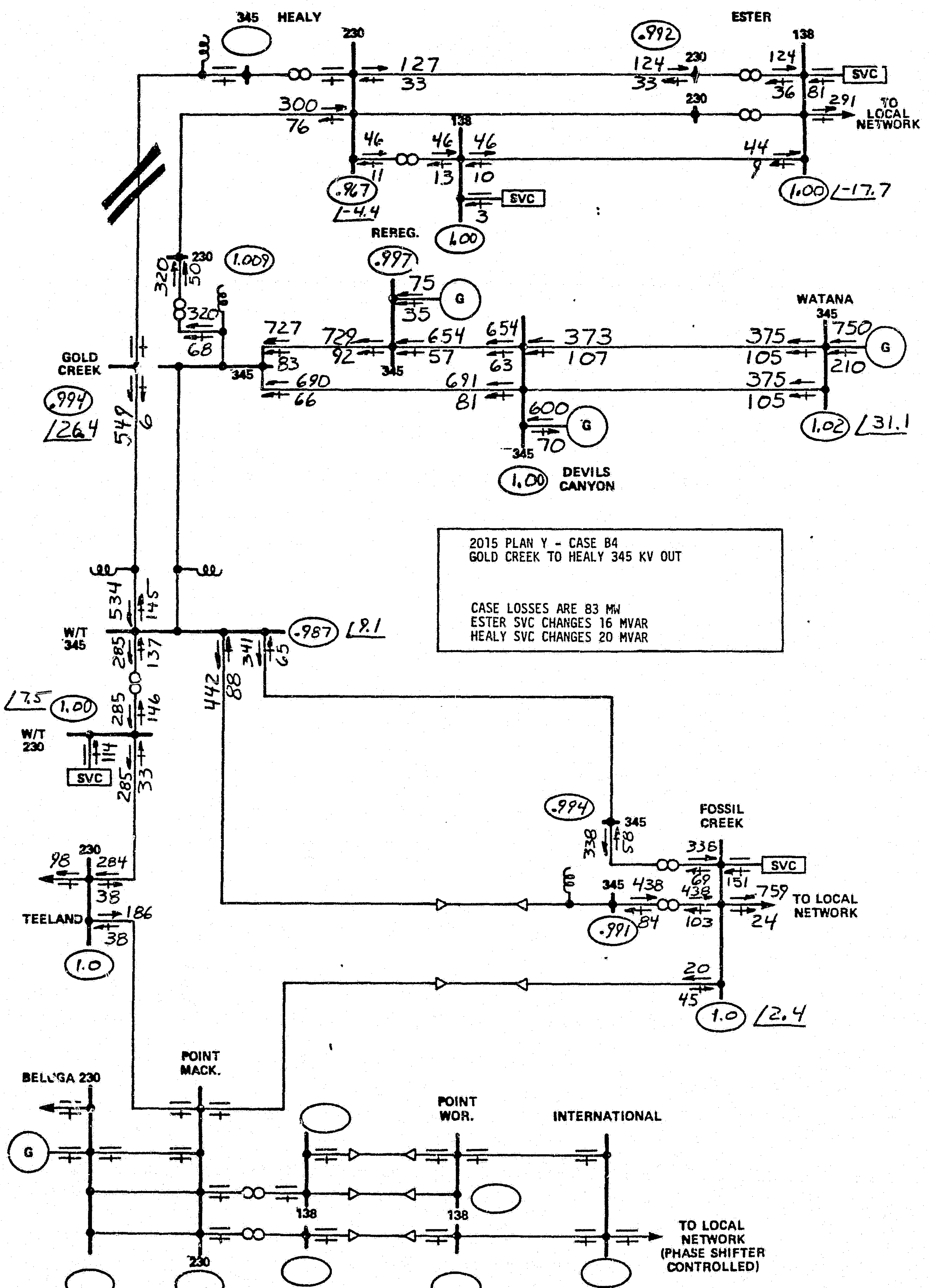
8.5

C10

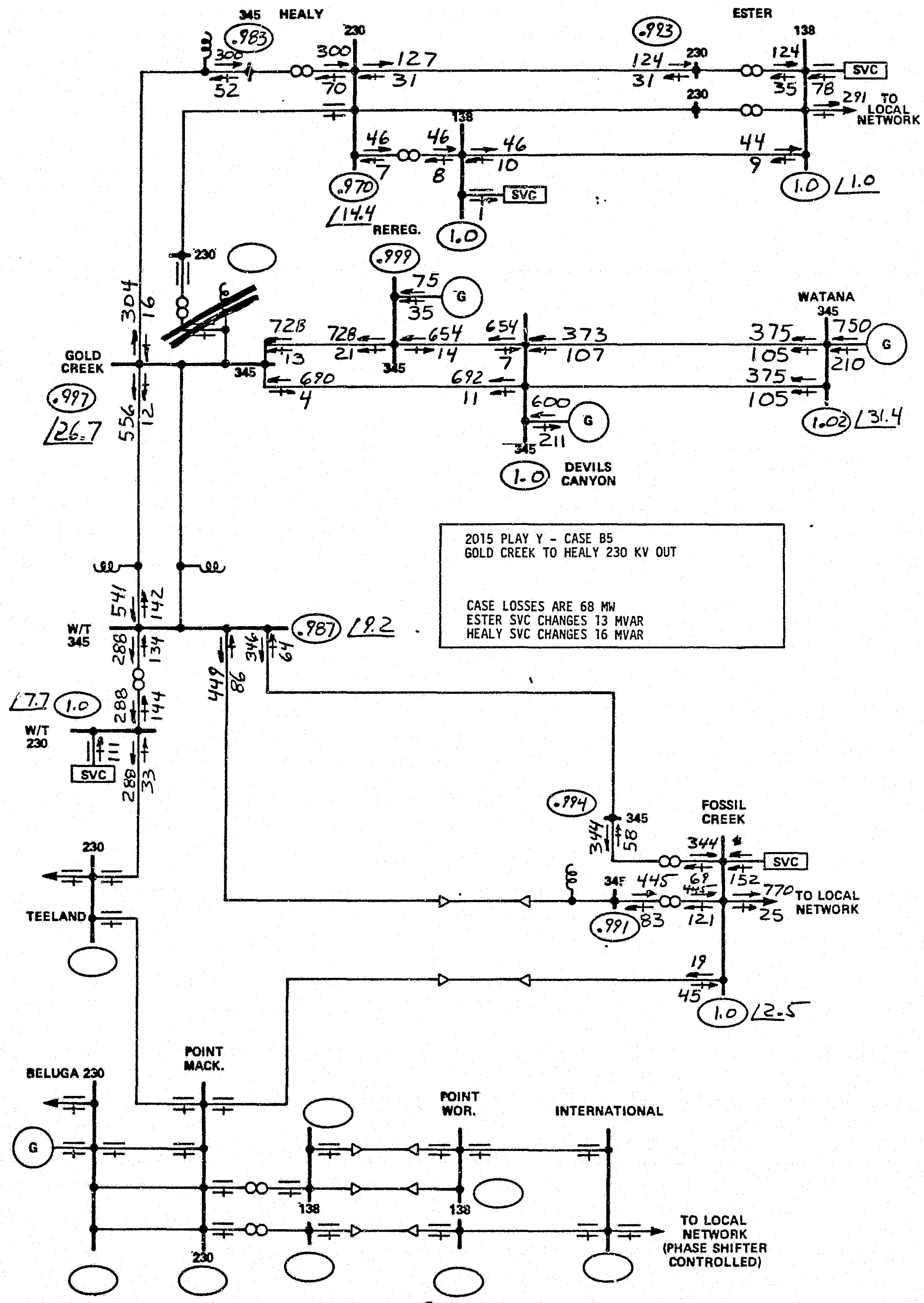


HEALY
ESTER
TO LOCAL NETWORK
REREG.
WATANA
GOLD CREEK
DEVILS CANYON
W/T 345
W/T 230
SVC
FOSSIL CREEK
TEELAND
BELUGA 230
POINT MACK.
POINT WOR.
INTERNATIONAL
TO LOCAL NETWORK (PHASE SHIFTER CONTROLLED)
2015 PLAN Y - CASE B3
GOLD CREEK TO W/T 345 KV OUT
CASE LOSSES ARE 102 MW
FOSSIL CREEK SVC CHANGES 63 MVAR
W/T SVC CHANGES 109 MVAR
MAXIMUM 345 KV INTERTIE LOADING

C 11

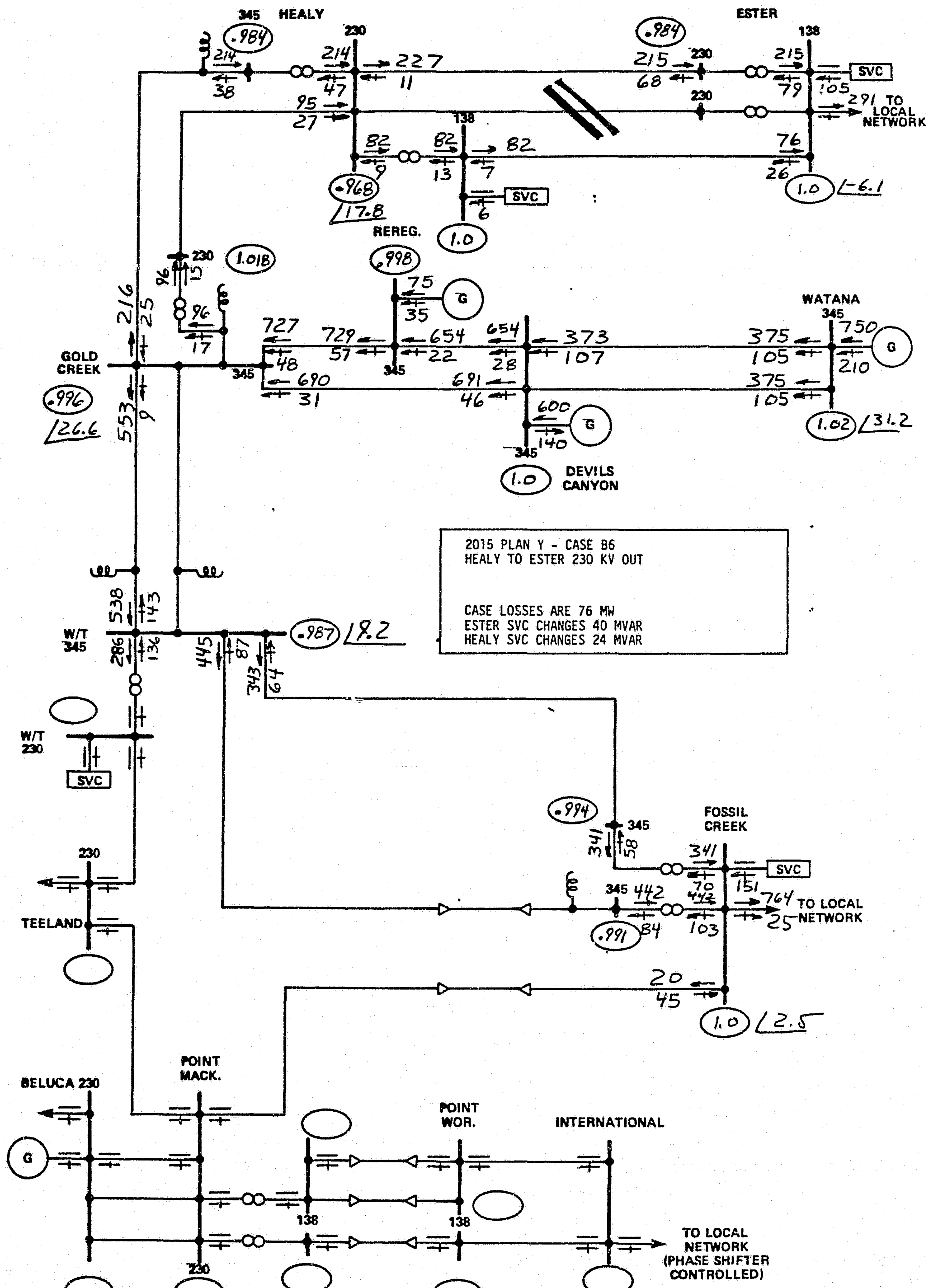

HEALY
ESTER
TO LOCAL NETWORK
REREG.
GOLD CREEK
WATANA
DEVILS CANYON
2015 PLAN Y - CASE B4
GOLD CREEK TO HEALY 345 KV OUT
CASE LOSSES ARE 83 MW
ESTER SVC CHANGES 16 MVAR
HEALY SVC CHANGES 20 MVAR
W/T 345
W/T 230
SVC
FOSSIL CREEK
TO LOCAL NETWORK
TEELAND
BELUGA 230
POINT MACK.
POINT WOR.
INTERNATIONAL
TO LOCAL NETWORK (PHASE SHIFTER CONTROLLED)

C 12


HEALY
ESTER
TO LOCAL NETWORK
SVC
REREG.
WATANA
GOLD CREEK
DEVILS CANYON
2015 PLAY Y - CASE B5
GOLD CREEK TO HEALY 230 KV OUT
CASE LOSSES ARE 68 MW
ESTER SVC CHANGES 13 MVAR
HEALY SVC CHANGES 16 MVAR
W/T 345
W/T 230
FOSSIL CREEK
TO LOCAL NETWORK
TEELAND
BELUGA 230
POINT MACK.
POINT WOR.
INTERNATIONAL
TO LOCAL NETWORK (PHASE SHIFTER CONTROLLED)

8.5

C 13


HEALY
ESTER
SVC
TO LOCAL NETWORK
REREG.
WATANA
GOLD CREEK
DEVILS CANYON
2015 PLAN Y - CASE B6
HEALY TO ESTER 230 KV OUT
CASE LOSSES ARE 76 MW
ESTER SVC CHANGES 40 MVAR
HEALY SVC CHANGES 24 MVAR
W/T 345
W/T 230
TEELAND
FOSSIL CREEK
TO LOCAL NETWORK
BELUCA 230
POINT MACK.
POINT WOR.
INTERNATIONAL
TO LOCAL NETWORK (PHASE SHIFTER CONTROLLED)

C 14