Attachment D

"Radiation Shielding of MI8 Beam Line",
Memo by J. Lackey (Oct. 1996)

VI.F.1

Fermilab
Accelerator Division
ES&H Department

10/24/96

NOV 0 1 1996
ACCELERATOR DIVISION
AD ES&H

TO: R. Pasquinelli, pbar Dept. Head

FROM: T. Leveling, AD RSO

SUBJECT: Temporary, Partial Transport Enclosure Shielding Assessment and Suggested Entry Controls to Permit Personnel Access to the MI-8 Enclosure During Transport Beam Operations

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The purpose of this memo is to advise you regarding the operating parameters which, if implemented, would allow personnel occupancy in the MI8 Enclosure beneath the Transport Enclosure during beam transfers in the Transport Enclosure.

Background

A series of calculations were made (Ref. 1) to determine radiation dose rates along the MI8 enclosure due to losses in the Transport enclosure from various sources. The purpose of the calculation was to determine where interlocked gates would need to be installed in the MI8 enclosure to ensure radiation exposure to non-radiation workers would be kept below the limits given by Reference 2. The use of interlocked gates would preclude access to the MI8 enclosure beneath the Transport enclosure during stacking, proton studies, pbar unstacking from the accumulator, and other beam transport operations through the AP2/3 lines. The use of interlocked detectors was not considered in Reference 1. Interlocked detectors are considered here to remove access constraints imposed by interlocked gates. The Main Injector Department would like to have contractor access allowed to this region so that construction activities may continue.

The shielding thickness in the region is 4.5 feet and includes a foot of steel over a limited portion of the enclosure. Ordinarily, the shielding would be equivalent to 6.5 feet of soil. However, the Main Injector Department advises that the steel should not be considered in the evaluation. The steel was placed specifically to ensure that accidental beam losses in the MI8 Enclosure would prevent excessive radiation levels on the berm surface. The area covered by the steel is not sufficient to entirely protect the MI8 Enclosure in the event of beam loss in Transport.

Normal Conditions

Some months ago, an interlocked detector was installed in the MI8 Enclosure beneath the Transport Enclosure to determine normal radiation levels during stacking. Personnel access to the area during beam operations in the Transport Enclosure has been prohibited by locked gates administratively controlled by the ES&H Department. Under conditions observed to date, the maximum continuous rates are approximately 1 mrem/hr. The projected rate at the Safety Envelope intensity limits is about 2 mrem/hr. The dose rates found for normal conditions will not restrict access for radiation worker trained personnel during beam transport operations. Some controls are necessary, however, to ensure that untrained personnel can not access this section of the MI8 Enclosure.

Accident Conditions

The accident conditions may be considered directly from the Dugan Criteria (Reference 3.) The limiting accident condition is a 1 E12 proton per cycle accident (a 100 mA pbar transfer lost at a point). If locked gates and interlocked detectors are used, 5.4 feet of shielding is required. Scaling the limiting beam intensity down to 5 E11 per cycle reduces the shielding requirement to 4.5 feet.

(continued on reverse side)

Conclusions

The highest normal dose rates in the enclosure are anticipated to be 2 mrem/hr. For the accident condition, if all existing pbar safety envelope limitations are observed and the maximum allowable pbar transfer is reduced from 100 mA to 50 mA, access could be permitted to persons who have radiation worker training. The limit on pbar transfers could be administratively controlled by a change to the Antiproton Source Beam Operations Permit and should not effect operations*. This beam permit limit could be removed when the final safety systems are installed which are to exclude personnel access to both enclosures when either the MI8 or Transport are transporting beam.

Some form of entry control will be required to ensure that only authorized radiation worker trained personnel can enter the MI8 Enclosure. The following entry control scheme is suggested:

1. Main Injector Department identifies those workers including contractors and lab employees who need to access the locked MI8 area.

2. The AD ES&H Department ensures that workers identified by the Main Injector Department have had Radiation Worker Training. (I or II).

3. The AD Radiation Safety Group provides a specialized briefing to workers to discuss:

   - access limitations (one key per person)
   - individuals responsibility to control traffic into area
   - gate controls (gates must be closed and locked when not attended)
   - purpose of interlocked detector and meter and flashing light indicators
   - dosimetry requirements

4. Upon completion of the briefing, the AD SSO or RSO issues a key to each trained individual which permits access to the locked MI8 region.

5. Individual workers who are issued keys would be required to read and sign a special Radiation Work Permit (RWP) which lists access control requirements. Copies of the RWP would be posted at each gate and would be required to be signed once per day by each specially trained person.

If you would like additional information on this assessment or the suggested entry controls, please let me know.

* Jim Morgan reports that historically, pbar transfers have been 10 to 15 mA and have never exceeded more than about 20 mA in a single batch.

References

1. C. M. Bhat and P. Martin, 'Radiation Level in the Intersection Region of AP2 and 8 GeV Beam-line due to Beam loss in the AP2 Beam-line
2. Fermilab Radiological Controls Manual
3. Memo from G. Dugan to J. Marriner, DD 3/21/91, Subject: Revised shielding criteria to define the "red line" in Antiproton Source shielding assessments

cc: H. Casebolt, C. Bhat, S. Holmes, P. Martin, D. Finley, D. Bogert, R. Mau, J. Morgan, K. Vaziri, D. Cossairt

pbar Shielding Assessment Files

B

Radiation Shielding of the MI8 beam line
(Booster to New enclosure)

I Operation to the AP4 Beam Dump

a) The Dugan Criterion (Ref. various Dugan Red Line Memo's circa 1991) According to the Dugan criterion for Booster and Booster extraction regions at the maximum permitted beam power (5e12p/p @ 1800 p/hr = 9e15p/hr) the required shielding thicknesses for no interlocked detectors are as listed below .

	Dose (mR/hr)	Magnet in Encl	Pipe in Encl	Buried Pipe
Unlimited occupancy	1	22.2'	19.8'	20.6'
Minimal Occupancy	10	16.2'	13.2'	17.6'
Signs and Ropes	100	14.1'	11.2'	15.5'

The beam line to the AP4 dump will have the same shielding as before plus some additional shielding in the form a new dirt berm. With the addition of the dirt berm outside the West Tower the minimum shielding thicknesses are now seen in the West Tower itself. These thicknesses vary upwards from 15.25'. Clearly there is not enough shielding present for unlimited occupancy in the West Tower. It will be necessary to either add shielding or use interlocked detectors.

According to the Dugan criterion for Booster and Booster extraction regions at the maximum permitted beam power (5e12ppp @ 1800 p/hr) the required shielding thicknesses for interlocked detectors are as listed below.

	Dose (mR)	Magnet in Encl	Pipe in Encl	Buried Pipe
Unlimited occupancy	0.25	14.3'	11.27'	15.67'
Minimal Occupancy	2.5	11.32'	8.38'	12.66'
Signs and Ropes	10.0	9.52'	6.64'	9.67'

The existing shielding thickness every where exceeds the 14.3' requirement above for a magnet in the enclosure. Interlocked detectors can be used to achieve an unlimited occupancy rating in the West Tower. It should be noted that the upstream end of the beam line has always had an interlocked radiation detector above the extraction septum and another was added after the Booster radiation safety assessment in 1991. It is very likely that only 1 or 2 more interlocked detectors will provide more than adequate coverage for the entire line to the AP4 dump but this will be determined by a shielding assessment before operation can resume.

b) The new enclosure

It is known that some radiation gets through the AP4 beam dump into the downstream enclosure. The intensity, energy and particle makeup of this beam is unknown. The new enclosure is mostly covered by steel shielding for the MI8 beam line. However part of the enclosure radially outward from the Booster is not covered by any shielding other than dirt. That part of the enclosure not covered by the steel has dirt coverage varying

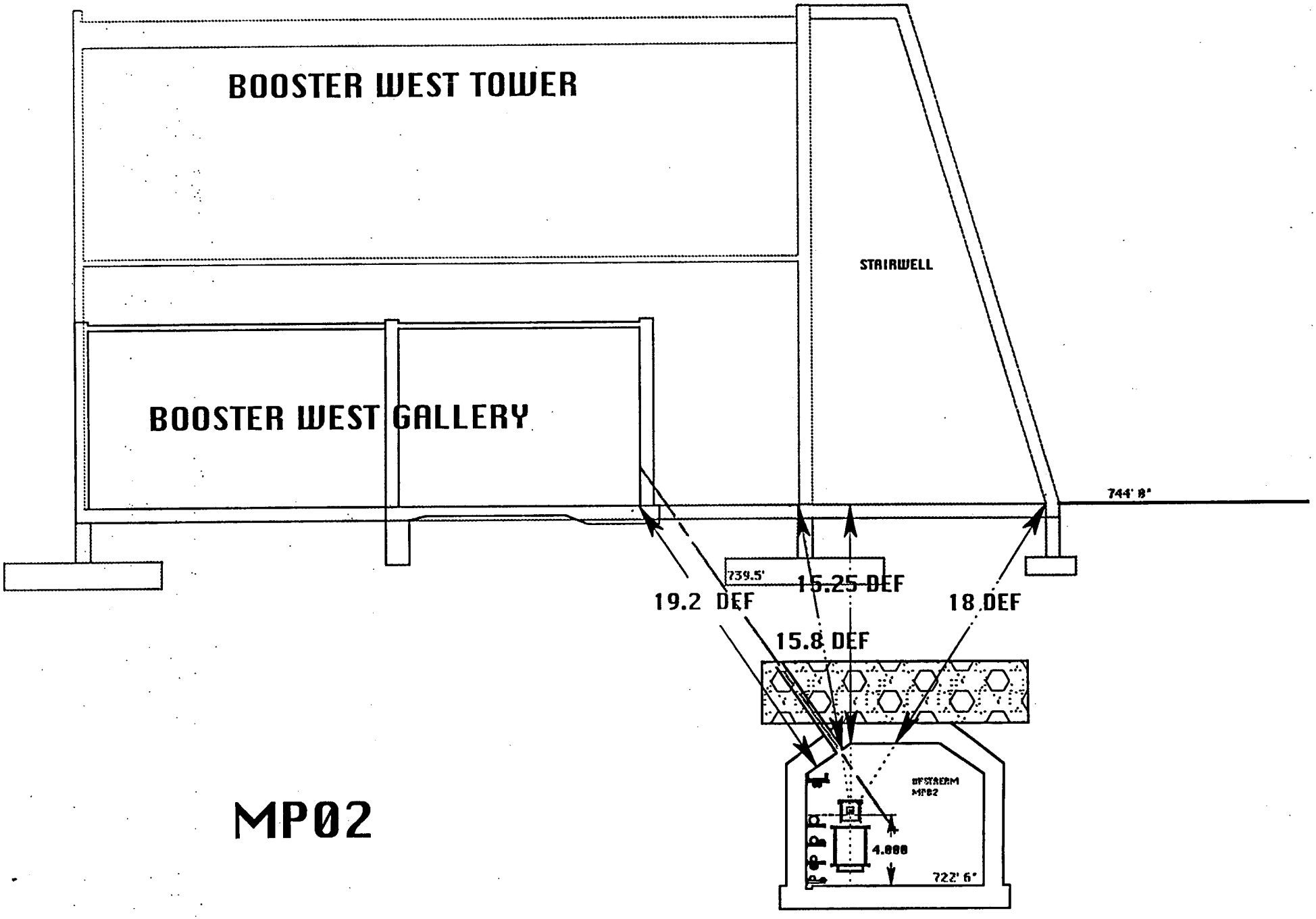
from 15.5' to 23.5'. Consequently it will be necessary to closely examine this area during the assessment to determine if any problem exists with the shielding.

II Operation to the MI 8 Beam Line

It is expected that operations to the AP4 beam dump will cease after the installation of the MI8 beam line components downstream of Q802. The shielding assessment up to the point of new installation will still be in effect however The assessment will have to be updated for the new elements with the expectation that the interlocked detectors may have to be moved or more added to provide complete coverage to past HEPB2.

The shielding after HEPB2 will be typically ~24.5' which will be adequate to meet the Dugan criterion scaled to NUMI intensities. See below.

	Dose (mR/hr)	Magnet in Encl	Pipe in Encl	Buried Pipe
Unlimited occupancy	1	24.7'	21.3'	26.1'
Minimal Occupancy	10	21.7'	18.4'	23.1'
Signs and Ropes	100	18.7'	15.5'	20.1'


BOOSTER WEST TOWER
STAIRWELL
BOOSTER WEST GALLERY
744' 8"
739.5'
19.2 DEF
15.25 DEF
18 DEF
15.8 DEF
4.000
722' 6"

MP02

BOOSTER WEST TOWER

MAX INTENSITY --- 9E15 protons/hour **No interlocked detectors**

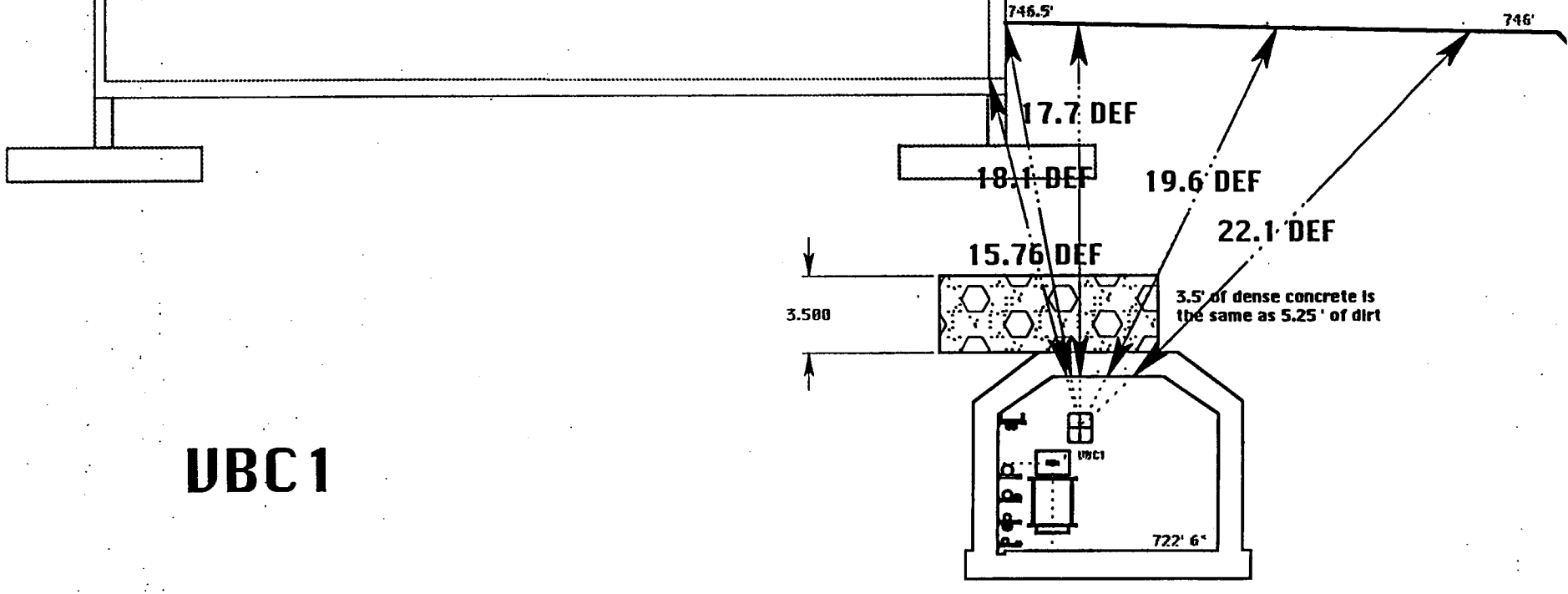
--- Required Dirt Equivalent feet of shielding---

	Dose (mR/hr)	Magnet in Encl	Pipe in Encl	Buried Pipe
Unlimited Occupancy	1	22.2'	19.8'	20.6'
Minimal Occupancy	10	16.2'	13.2'	17.6'
Signs and Ropes	100	14.1'	11.2'	15.5'

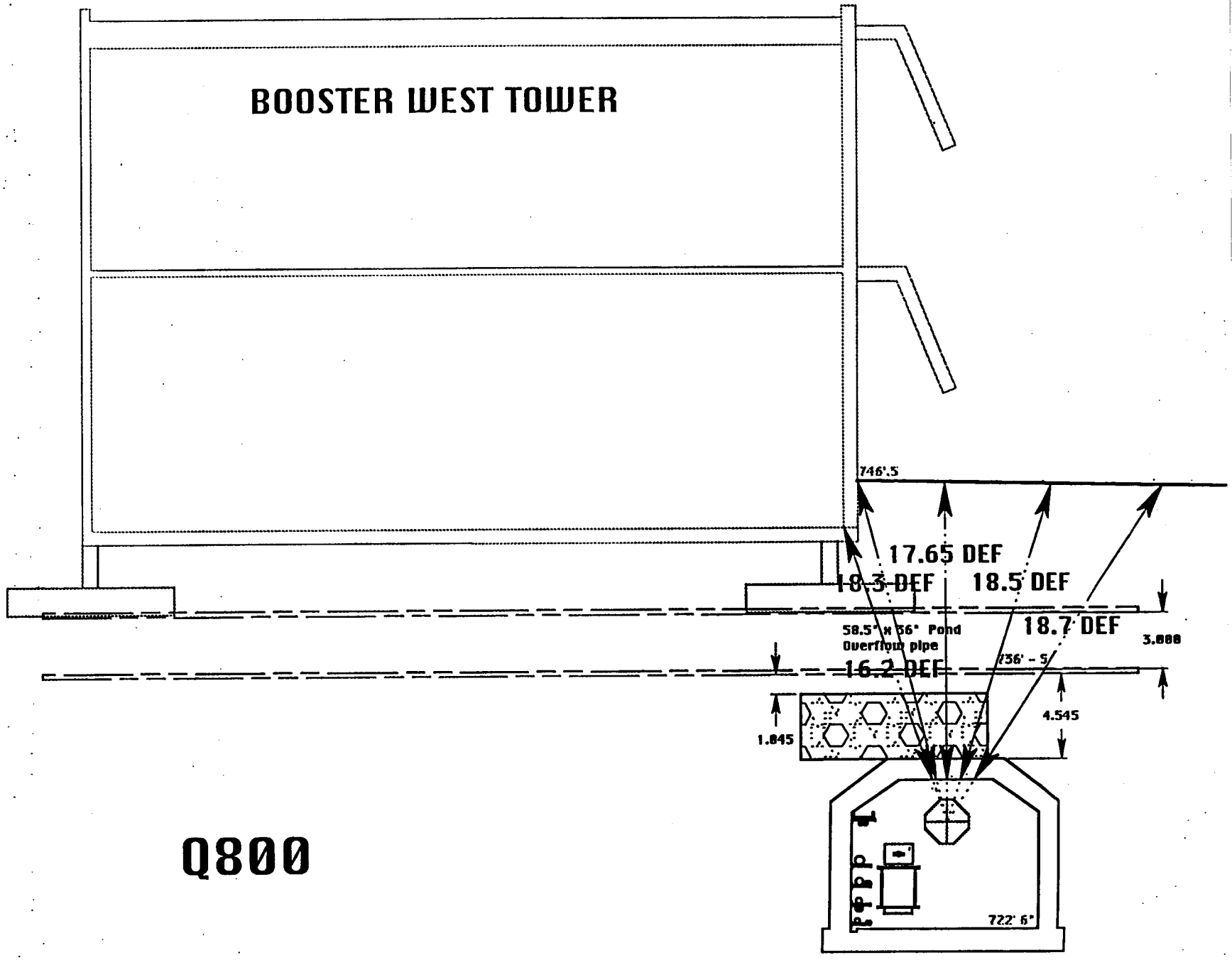
NUMI INTENSITY --- 6E16 protons/hour **No interlocked detectors**

--- Required Dirt Equivalent feet of shielding---

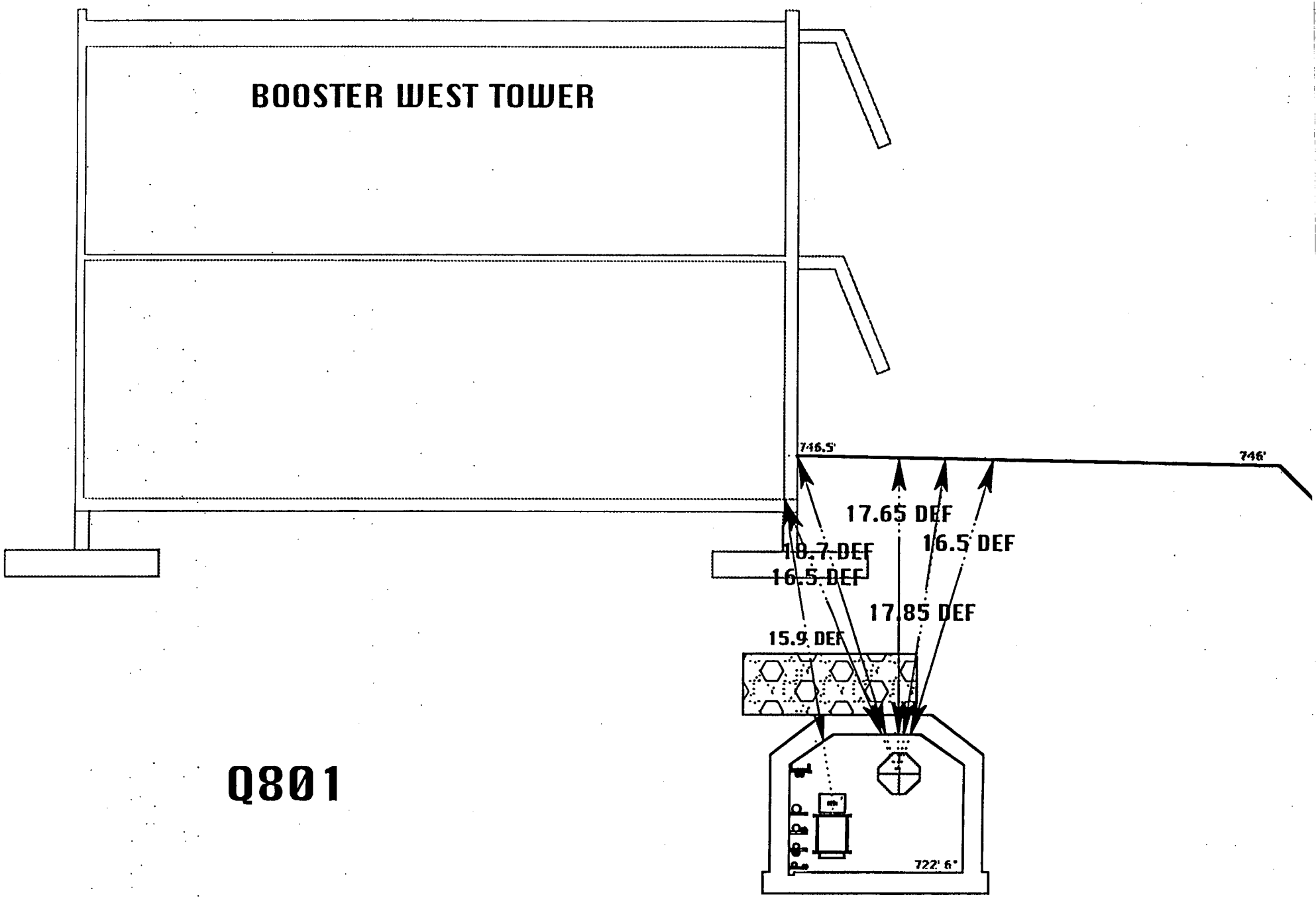
	Dose (mR/hr)	Magnet in Encl	Pipe in Encl	Buried Pipe
Unlimited Occupancy	1	24.7'	21.3'	26.1'
Minimal Occupancy	10	21.7'	18.4'	23.1'
Signs and Ropes	100	18.7'	15.5'	20.1'



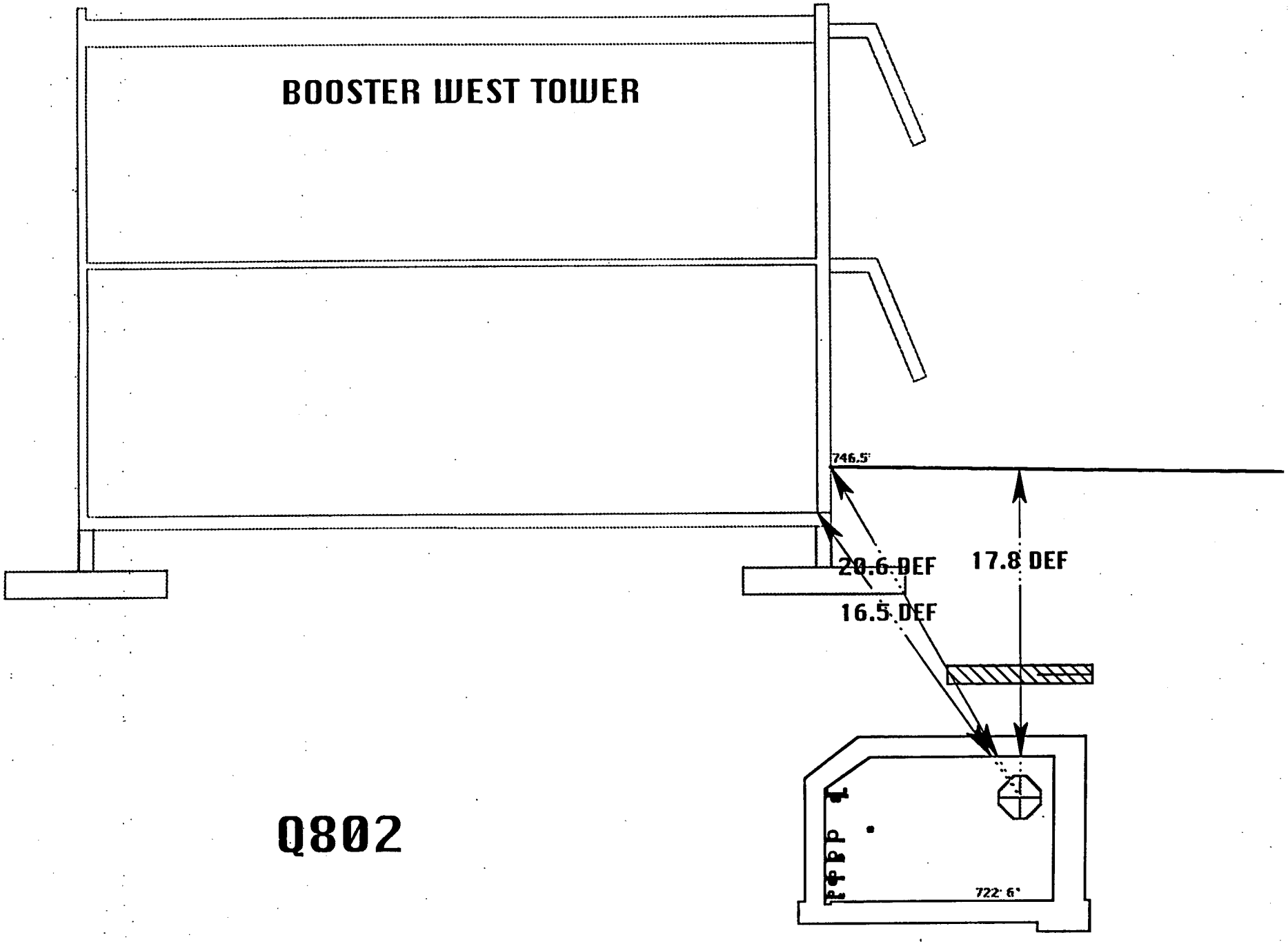
UBC1


BOOSTER WEST TOWER
746'.5
17.65 DEF
18.3 DEF
18.5 DEF
18.7 DEF
58.5° N 56° Pond
Overflow pipe
16.2 DEF
736' - 5
3.888
4.545
1.845
722' 6"

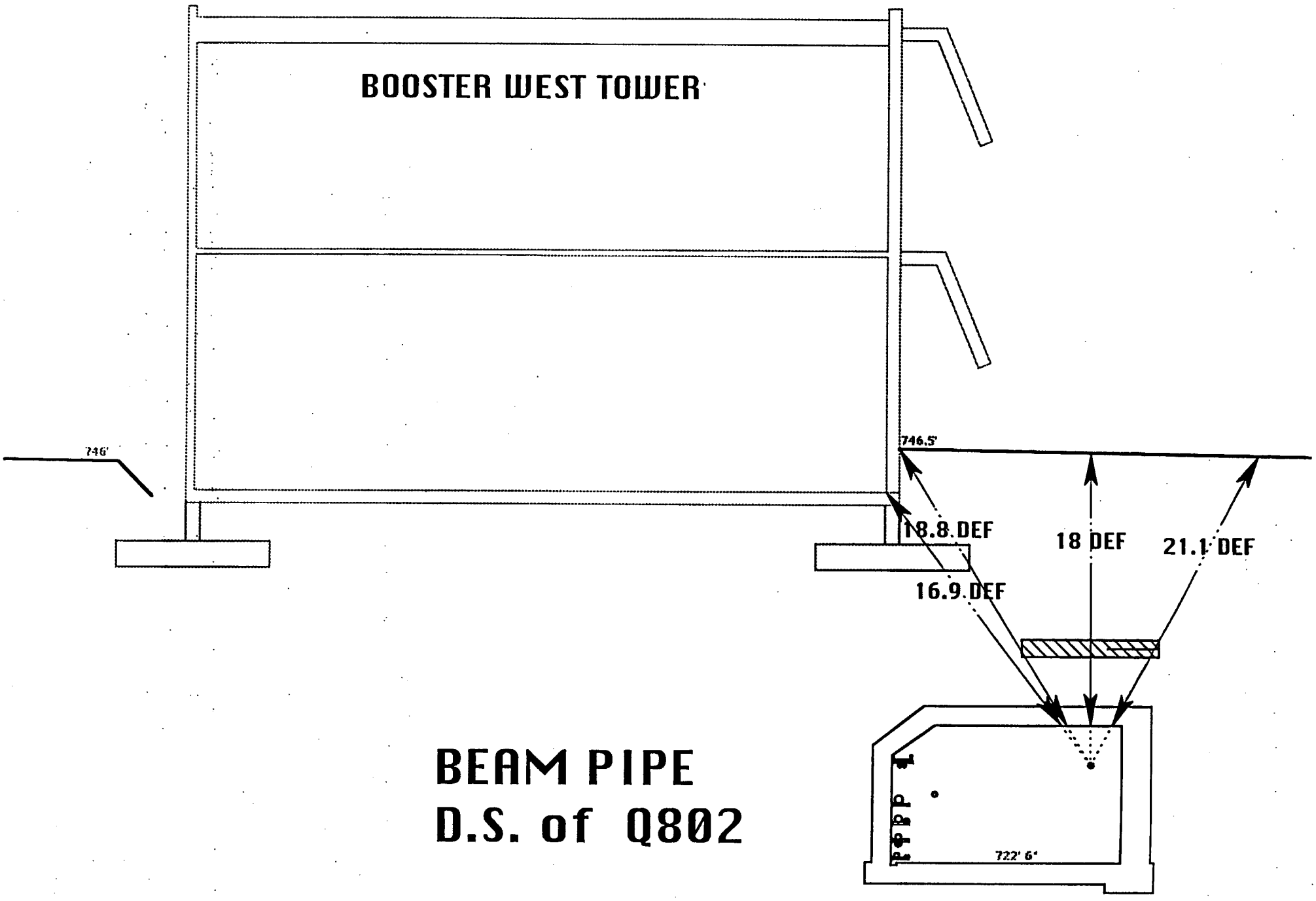
Q800


BOOSTER WEST TOWER
746.5'
746'
17.65 DEF
16.5 DEF
18.7 DEF
16.5 DEF
17.85 DEF
15.9 DEF
722' 6"

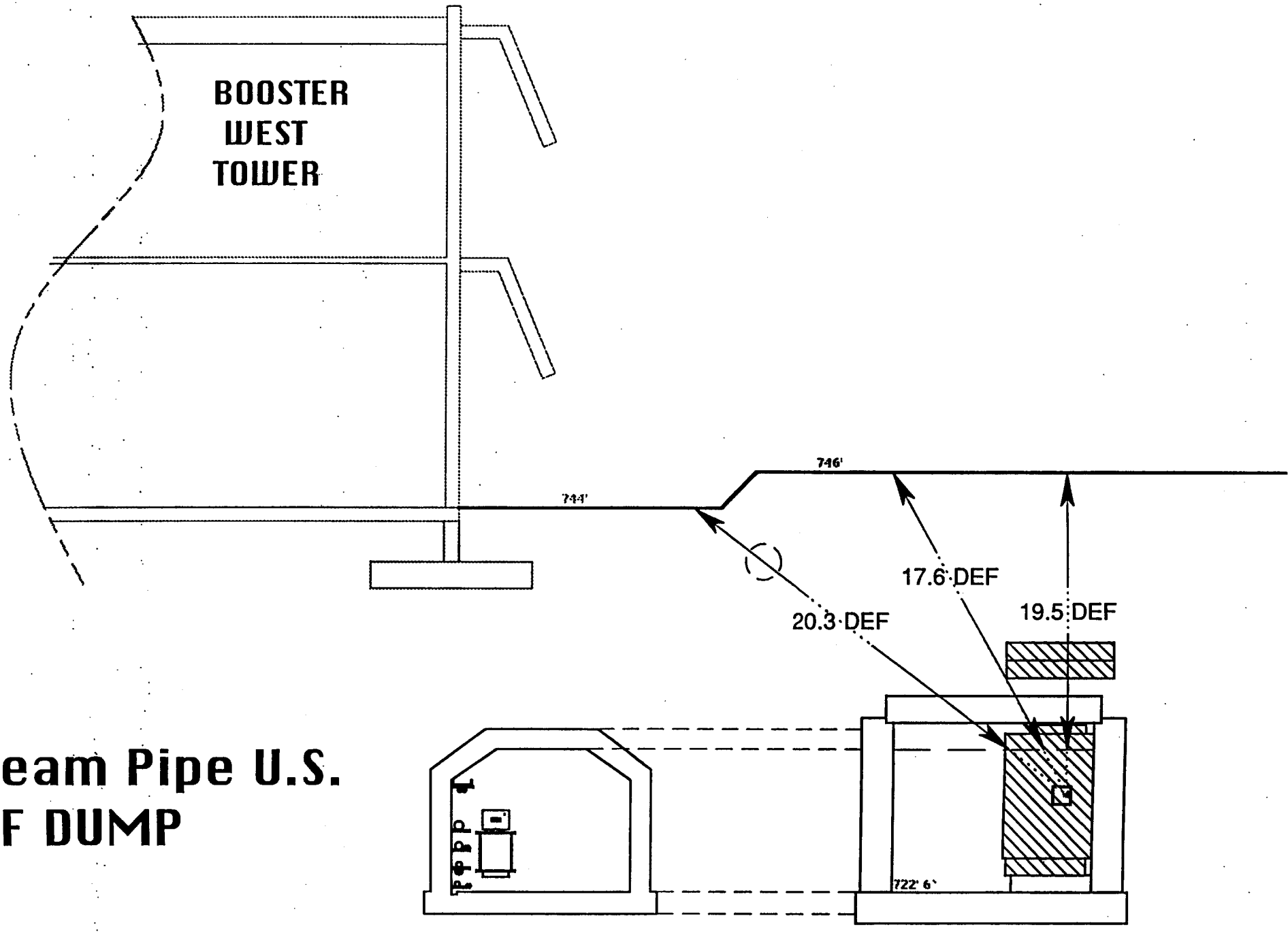
Q801



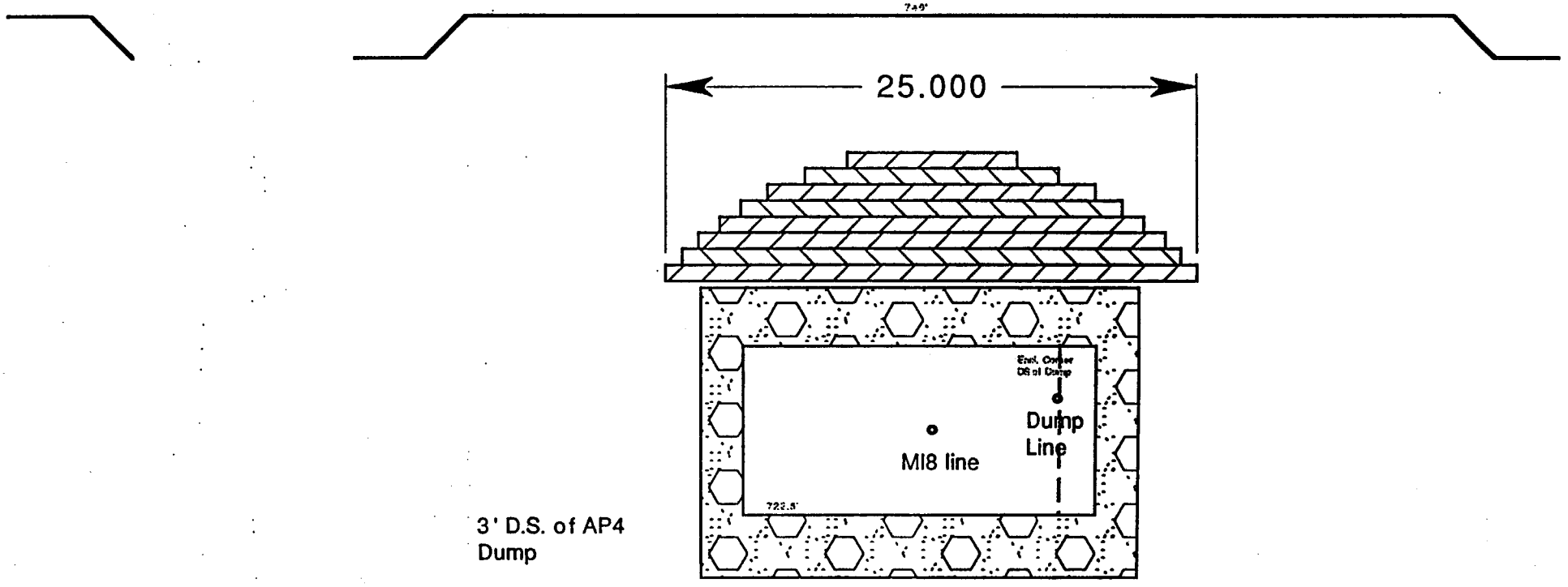
Q802



BEAM PIPE
D.S. of Q802



Beam Pipe U.S. OF DUMP



3' D.S. of AP4
Dump

11/27/96

To: D. Finley, AD Head

From: D. McGinnis, Proton Source Dept. Head David McGinnis 11/27/96

Subject: Temporary MI8/AP4 Radiation Shielding Assessment

Reference: MI8/AP4 Radiation Shielding Assessment Run Plan, dated 11/12/96

Introduction: This memo states results of the Temporary Radiation Shielding Assessment Studies of the 8 Gev beam line from Booster Long 3 to the AP4 dump conducted in accordance with the referenced plan. The results of this temporary assessment will become part of the final assessment that will be done when the installation of the remainder of the MI8 beamline is completed.

Beam Loss Studies: The point of these studies was to get experimental data for radiation generated by beam losses on the various beam line elements in order to check the effectiveness of the existing shielding and interlocked detector scheme for the current occupancy of the WBT and adjacent areas. ~~This line was not studied for high intensity beam operation in the 1991 assessment.~~ We needed to verify that the losses due to high intensity operation are adequately limited by the existing shielding and interlocked detectors. The tests that were done are listed below.

Previous assessment are replaced by new assessment

1) MP02 -- Dump beam off the extraction septum. Measure losses downstream above ground and in the 1st floor offices of the West Booster Tower.

2) VBC1 -- Dump beam in the VBC1 magnet. Measure losses downstream above ground and in the 1st floor offices of the West Booster Tower.

3) Downstream of Dump -- Based on measurements made last winter (1995/1996), it is known that significant radiation leaks through the dump into the new enclosure. Detectors were placed to look for losses at points where the shielding is thinnest above the enclosure downstream of the dump.

In the referenced plan, we had stated an intention to examine radiation levels due to losses on three quadrupoles in the AP4 line which are downstream of VBC1. We concluded based on test 2 above that the existing buried detector located outside and adjacent to the West Booster Tower would provide necessary protection in the event of losses on those quadrupoles. In addition, it was determined that insufficient horizontal bending capability presently exists to steer beam into those quadrupoles.

Assessment results:

1) The beam loss tests on the extraction septum revealed that the interlocked detector in the stairwell of the West Tower was not located on the peak loss point. It was necessary that the detector be moved from the north wall of the stairwell to the south wall of the stairwell to place it on the peak loss point. This has been done. In the new position the detector will adequately limit losses to allowable levels for both the accident and normal loss conditions. It is also necessary to post the sidewalk area outside the north entrance of the tower (adjacent to the stairwell) as a controlled area. This is because the resulting dose rates from normal losses due to extraction at Safety Envelope intensity will exceed 0.25 mrem/hr, the posting threshold for minimal occupancy.

2) The beam loss test on the 5 foot vertical dipole, VBC1 showed that the buried detector located outside the West Tower and above Booster long straight four detects the

losses on VBC1 and limits dose rates in and outside the West Tower to allowed levels. No changes to the interlocked detector is required.

3) The area above ground and downstream of the AP4 beam dump was checked. The only measurable radiation in this area was directly above the beam dump itself. The dose rate at this point is acceptable for both the accident and normal loss conditions.

In summary, the sidewalk at the southwest corner of the West Booster will be posted as a controlled area and the West Stairwell detector should be moved several feet to a new permanent location. This combination of existing interlocked detectors, shielding, occupancy, and area posting meet the requirements of the Fermilab Radiological Controls Manual for beam extraction to the AP4 line dump..