HYDRAULIC CONTROL PLAN
INDIAN POINT ENERGY CENTER
BUCHANAN, NEW YORK

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July 19, 2006
41.0017869.10

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1.00 INTRODUCTION

This report presents an outline of alternatives to hydraulically control portions of the groundwater currently flowing beneath the Indian Point Energy Center (IPEC) in Buchanan, New York ("Site"). It was prepared at the request of Enercon Services, Inc., on behalf of Entergy Nuclear Northeast, Inc., by GZA GeoEnvironmental, Inc. (GZA). A Site Locus Plan is provided as Figure No. 1.

1.10 PURPOSE

This report was prepared to facilitate planning, in a format that assumes the reader is at least somewhat familiar with groundwater issues at the Site. Its purpose is to: (1) identify methods to hydraulically control and capture selected portions of the groundwater beneath the IPEC; (2) outline the steps required to implement control measures; (3) provide an estimate of the implementation time required; and, (4) control releases at the sources and reduce/inhibit potential for migration of contamination away from the source areas. It should be noted that low levels of contamination outside the capture zone will migrate towards the river and eventually dissipate.

1.20 LIMITATIONS

The groundwater investigations are on-going. Therefore, our understanding of field conditions is still evolving. Further, the groundwater flow of interest is in a fractured rock aquifer. The size and location of all fractures and aquifer heterogeneities will never be fully identified. Consequently, implementation of control measures will, by necessity, be somewhat iterative and subject to field modifications.

2.00 BACKGROUND

Low levels of groundwater contamination have been found at the facility. Initial testing and observations made during construction identified the Unit 2 Spent Fuel Pool (IP2-SFP) Structure as a source of tritium in groundwater.

Subsequent sampling and analysis of groundwater, collected down gradient of that structure, found strontium 90, and other contaminants in groundwater. The Unit 1 Fuel Storage Building (IP1-FSB) and/or the Unit 1 Containment Spray Sump (IP1-CSS) have been identified as the likely source of that groundwater contamination.

3.00 NATURE OF CONTAMINANTS

Based on testing completed to date, the two contaminants of concern are tritium and strontium 90. That is, it appears that other groundwater contaminants are associated with the same source areas, and addressing these two contaminants will remediate facility groundwater.

Both tritium and strontium 90 are soluble in water at the pH observed at the site, and therefore migrate with groundwater flow. Tritium is mobile, as evidenced by its' use as a tracer in groundwater studies. Conversely, strontium 90 has an affinity for aquifer materials and reportedly has a very strong affinity for clays. A measure of this affinity is the distribution coefficient (Kd). The Kd for strontium 90 in soils has been reported to vary by five orders of magnitude, apparently depending on both the pH of the water and the clay content of the aquifer matrix. This indicates that tritium is migrating at rates commensurate with the groundwater seepage velocity, and strontium 90 migration rates are significantly less (perhaps less than 1/30) of the groundwater seepage velocity

4.00 BEDROCK PROPERTIES

The migration pathways of potential concern are in the native rock, broken rock created during the construction of the facility, and in soil (both native and backfill). The pathways of concern, identified to date are largely in the native and broken rock, although strontium 90 has been detected in overburden adjacent to the IP1-FSB and along the eastern wall of the discharge canal.

4.10 EQUIVALENT BULK HYDRAULIC CONDUCTIVITY[1]

The shallow bedrock is well fractured, with an observed fracture spacing on the order of 2 to 10 feet. These fractures are also hydraulically active with equivalent bulk hydraulic conductivities (as measured by packer testing) averaging approximately 1×10^{-4} cm/sec (0.3 ft/day).

4.20 EQUIVALENT TRANSMISSIVITY[1]

Based on these measurements, the size of the watershed, areal recharge, and preliminary modeling, we estimate that the average equivalent transmissivity of the shallow rock is on order of 50 $feet^2$/day. We note, however, the bedrock has significant heterogeneities, and the transmissivity (and consequently the yield of wells) varies greatly over short distances.

4.30 DEPTH OF CONTAMINATION

The depth of contamination has not yet been characterized. For planning purposes, at this time, we have assumed the contamination is limited to the upper 100 feet of the bedrock.

4.40 HYDRODYNAMIC DISPERSION

Hydrodynamic dispersion is a term that describes the mechanical process that causes contaminated water to mix with ambient groundwater flow. That process causes the leading edge of the contamination to move faster than the average contaminant mass, and for the contaminated zone to become wider and thicker with distance from the source area. That spreading, in turn, reduces the concentrations of contaminants found in groundwater.

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1. Terms like hydraulic conductivity and transmissivity are defined and typically used in describing groundwater movement through a porous medial (e.g., granular soil). When applied to a fractured bedrock regime, the term "equivalent" is often used to note that the parameter value is not for a true porous media, but for a fractured media that has hydraulic characteristics that appear to be similar to a porous media.

The degree of hydrodynamic dispersion is generally a function of the grain size (in porous media) and the size of heterogeneities. While there is currently insufficient data to estimate dispersifity coefficients, we believe this parameter may generally be large and hydrodynamic dispersion may complicate capturing all contaminated groundwater at down gradient locations.

4.50 SORPTION

The bedrock aquifer contains clays, and other materials such as iron percipitates, within the fractures that would cause strontium 90 (and other contaminants) to partition from groundwater to the rock mass. In addition, there are likely small "dead end" fractures that will "store" contaminated groundwater that entered these "pores" through diffusion processes. Because these processes are largely reversible, the net effect will be to retard the migration of contaminants, and slow any remedial efforts. With existing information, it is not possible to quantify these effects. We believe, however, that while hydraulic containment can be achieved quickly (within days of effective pumping) remediation will likely take years, even if all leaks could be stopped.

5.00 GROUNDWATER CONTAINMENT

We evaluated groundwater extraction measures that could be implemented to control the migration of contaminated groundwater. In performing the evaluation we assumed the extracted water would be treated (if necessary) and released to the discharge canal. Consequently, we did not evaluate groundwater recharge schemes.

We performed the evaluation by mathematically treating the saturated rock as an equivalent porous media. On the scale of the watershed, this approach is very reasonable. When locating individual wells, however, it is likely that significant variations in the hydraulic properties, over short distances, will demonstrate a weakness in this approach.

Because of the aquifer, heterogeneities we believe the capture zones of individual extraction wells will likely be either larger or smaller than predicted; and, it may prove necessary to use an observational approach in completing the extraction system. Consequently, we anticipate that it will be necessary to install wells, and subsequently modifying well locations and pumping rates based on the observed response of the groundwater flow field. The alternative to this approach, extensive testing and rock fracture modeling, would be very time consuming, expensive, and currently offers few, if any, obvious advantages over the proposed observational approach.

5.10 PROPOSED LOCATIONS

We identified three potential locations where pumping should be effective in limiting migration of identified contaminants of potential concern. These locations were selected based on the observed contaminant distribution, observed and modeled groundwater flow paths, and location access.

The required pumping rates and the resulting capture zones were estimated by use of an equivalent porous media flow model. While this model appears to provide a reasonable representation of flow conditions, it has not been fully calibrated. Consequently, while it represents the best that can be done with the available information, for reasons previously discussed, its use as a predictive tool is limited.

5.11 Location A – Unit 2 Fuel Storage Building

The IP2-SFP is an identified source of the tritium contaminated groundwater. An extraction well within the IP2-FSB within 4 feet of existing well MW-30 (see Figure No. 2) has the potential of capturing the tritium-contaminated groundwater, and it appears unlikely that pumping at this location would exacerbate the strontium 90 plume associated with Unit 1. (Note: an alternative pumping location to control the IP2-FSB source would be the transformer yard, but this location would likely require a higher extraction rate for the same level of containment and could necessitate another well[s] being required at IP1-FSB to limit the potential for induced strontium migration from Unit 1 towards Unit2). Required extraction rates would likely be in the range of 1 to 4 gpm (200 to 800 cubic feet/day). The extracted groundwater could have tritium concentrations as high as 600,000 pCi/l.

5.12 Location B – Unit 1 Superheater Building

Based on existing information, the source of the strontium 90 in groundwater is either (or possibly both) the IP1-FSB or the IP1-CSS. We also note it is not clear why contaminated groundwater from the IP1-FSB (if it is a source) is not being intercepted by the Unit 1 underdrain system.

In part because of the effects of that underdrain, an extraction well placed in the Superheater Building, down gradient of the Spray Contaminant Sump (in the vicinity of the stack – see Figure No. 3) has the potential to capture the strontium 90 contaminated groundwater originating from either or both locations. Required extraction rates at this location would likely also be in the range of 1 to 4 gpm (200 to 800 cubic feet/day). The extracted groundwater could have strontium 90 concentrations as high as 40 to 300 pCi/l. Note if subsequent studies identify the IP1-FSB as the only source of strontium 90 contamination, we would likely wish to revisit the proposed location of this extraction well.

5.13 Location C – West of Discharge Canal

Strontium 90 has been found in samples collected from monitoring wells (MW-37 and MW-49) located west of the discharge canal. If up gradient containment is not totally effective, or if it becomes important to capture the down gradient, leading edge of the contamination, it may be required, or advisable, to install an extraction well (or wells) to the west of the discharge canal (see Figure No. 4). A tentative location for this well is west of the Unit 1 Turbine Generator Building (IP1-TB). The required extraction rate at this location is estimated to be on the order of 4 to 8 gpm. However, the location, and hydraulic connection between the bedrock and the discharge canal render additional uncertainties to this estimated pumping rate. At this location, we believe the strontium 90 concentration would likely be less than 30 pCi/l.

5.20 EXTRACTION WELL CONSTRUCTION

Based on the estimated extraction rates, we recommend the installation of 6-inch diameter extraction wells. These wells could be used to accommodate up to 4-inch electrical submersible pumps.

The wells would be cased into the bedrock to prevent soils from raveling into the bore hole. Based on the observed stability of the rock, we anticipate using open bedrock bore holes to an elevation at or below 25 feet. The exact depth of the extraction wells will be determined following completion of our investigations.

6.00 IMPLEMENTATION

As an overview, implementation will require, drilling of extraction wells, piping to treatment units (if required) and discharge locations, and permitting (if required). We understand the facility will manage piping, treatment, and permitting.

Based upon our conversations with IPEC engineering personnel, GZA understands that the recovery well installed within the IP2-FSB will need to be completed in July 2006. GZA is currently installing this well. In addition, plumbing will need to be installed prior to completion of the floor slab. At this point GZA recommends that the plumbing be brought out of the IP2-FSB in the direction of the most likely discharge point and stubbed to the surface for future connection to the discharge point. In addition, conduit for power and control wiring should be installed during this work.

For other proposed recovery wells, we believe the required drilling equipment can be mobilized within three to four weeks of being given Notice to Proceed. For planning purposes, we recommend budgeting for two extraction wells for each selected location. Drilling will take on the order of 4 to 6 days per extraction well depending on depth and logistical considerations.

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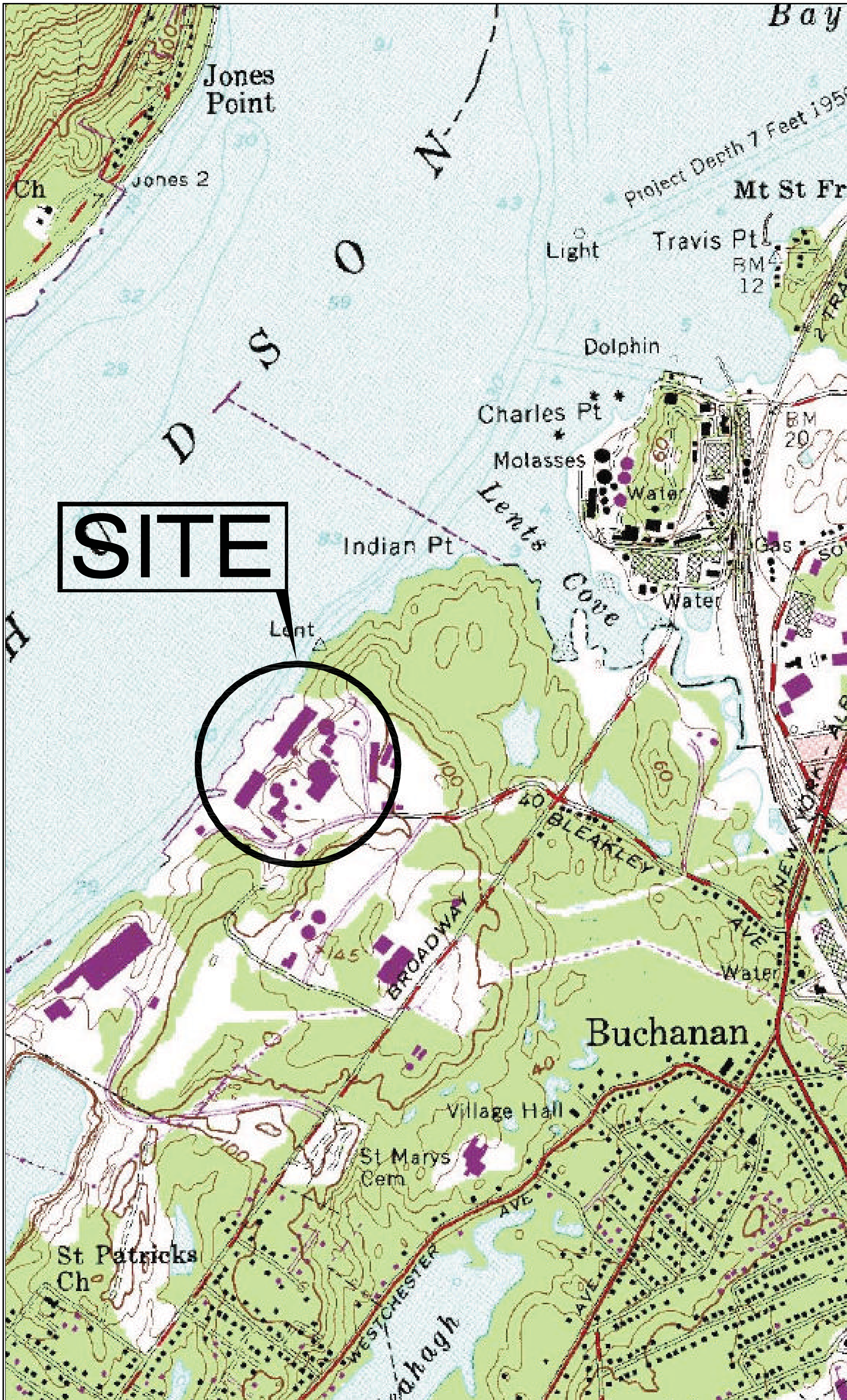
FIGURES



REV. NO.	DESCRIPTION	BY	DATE

PROJ MGR: DW
DESIGNED BY: MJG
REVISED BY: MJG

DRAWN BY: MJG
APPROVED BY: MJB
DATE: 07-19-06

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BUCHANAN, NY

LOCUS PLAN

PROJECT NO.
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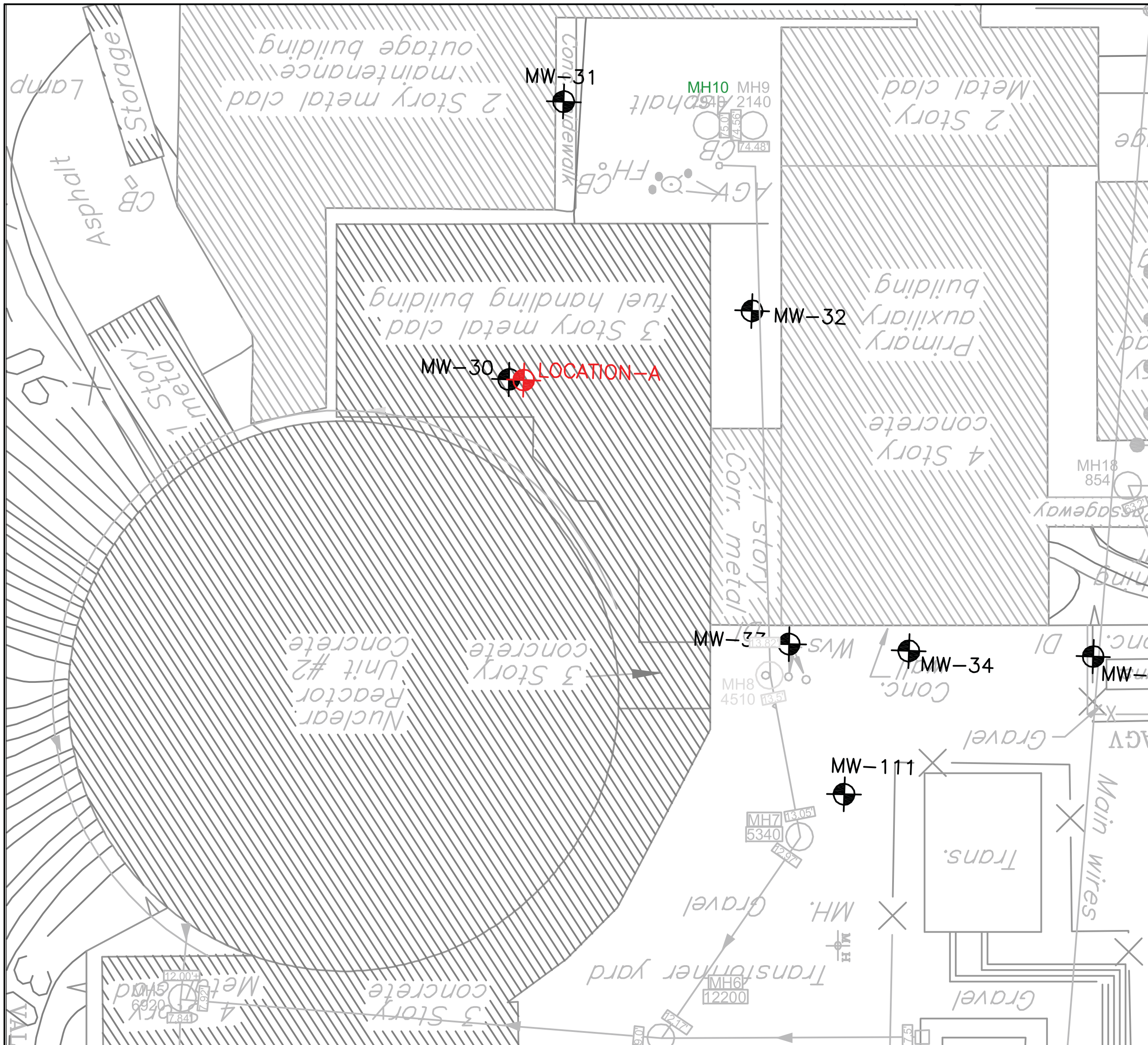
FIGURE
1



LEGEND:

MW-39	MONITORING WELL
LOCATION-A	HYDRAULIC CONTROL WELL

NOTES:

1. BASE MAP DEVELOPED FROM ELECTRONIC FILES, PREPARED BY BADEY AND WATSON SURVEYING & ENGINEERING PC, COLD SPRING, NY 10516.

FIGURE	PROJECT NO.		
2	41.0017869.10	INDIAN POINT ENERGY CENTER BUCHANAN, NY	REMEDIATION WELL LOCATION A

REV. NO.	DESCRIPTION	BY	DATE

SCALE

0 50FT.

PROJ MGR: DW
DESIGNED BY: MJG
REVISED BY:
DRAWN BY: MJG
APPROVED BY: MJB
DATE: 07-19-06

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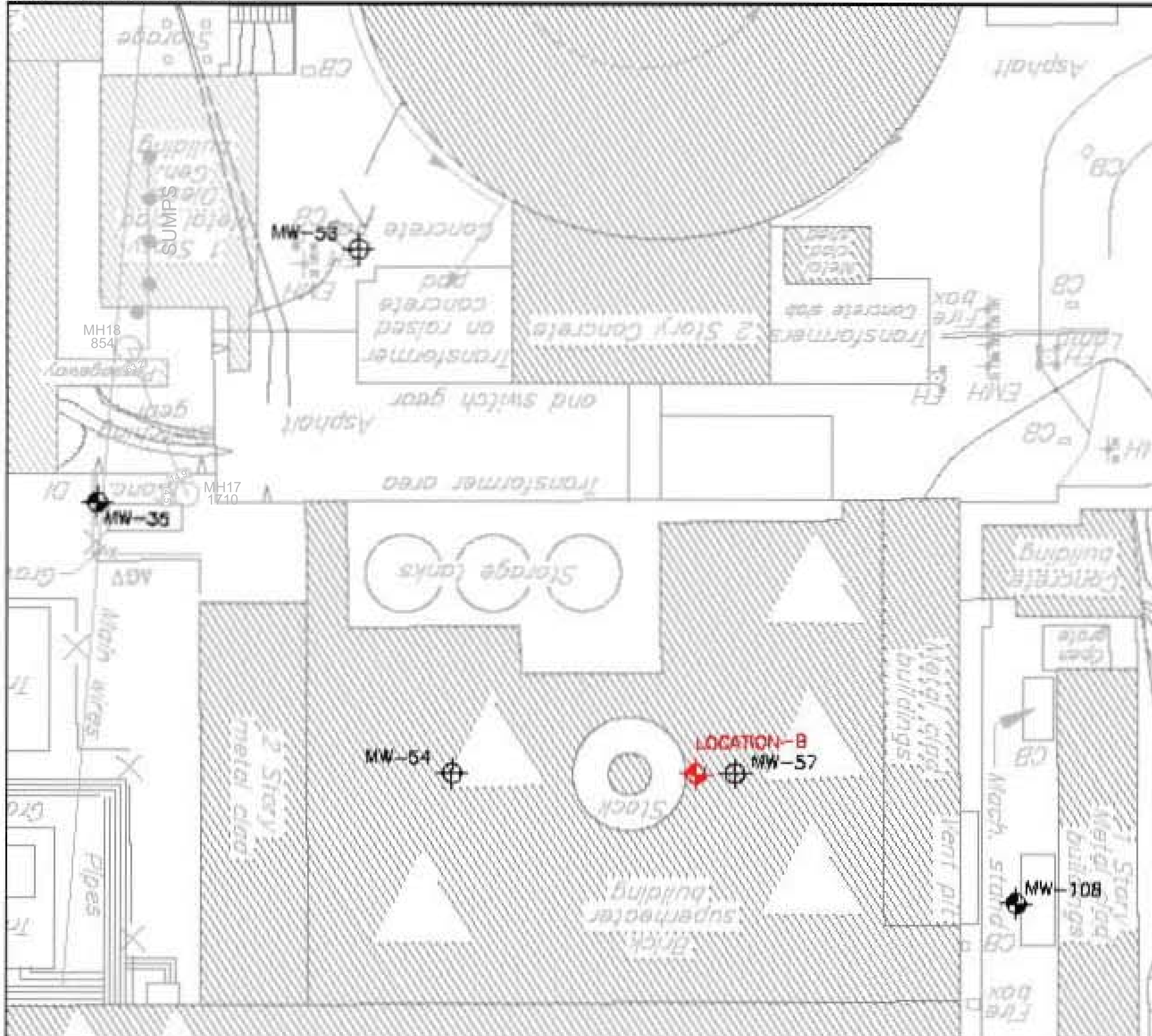
LIVONIA, MICHIGAN 48150

N:\cadfiles\IndianPoint\remediation_report\FIGURE 2.dwg, Layout4, 8/4/2006 8:20:02 AM, 1:1



LEGEND:

MW-39	MONITORING WELL
LOCATION-A	HYDRAULIC CONTROL WELL

NOTES:

1. BASE MAP DEVELOPED FROM ELECTRONIC FILES, PREPARED BY BADEY AND WATSON SURVEYING & ENGINEERING PC, COLD SPRING, NY 10516.

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BUCHANAN, NY

REMEDIATION WELL
LOCATION B

PROJECT NO. 41.0017869.10

FIGURE 3

REV. NO.	DESCRIPTION	BY	DATE

SCALE 0 50FT.

PROJ MGR: DW
DESIGNED BY: MJG
REVISED BY:

DRAWN BY: MJG
APPROVED BY: MJB
DATE: 07-19-06

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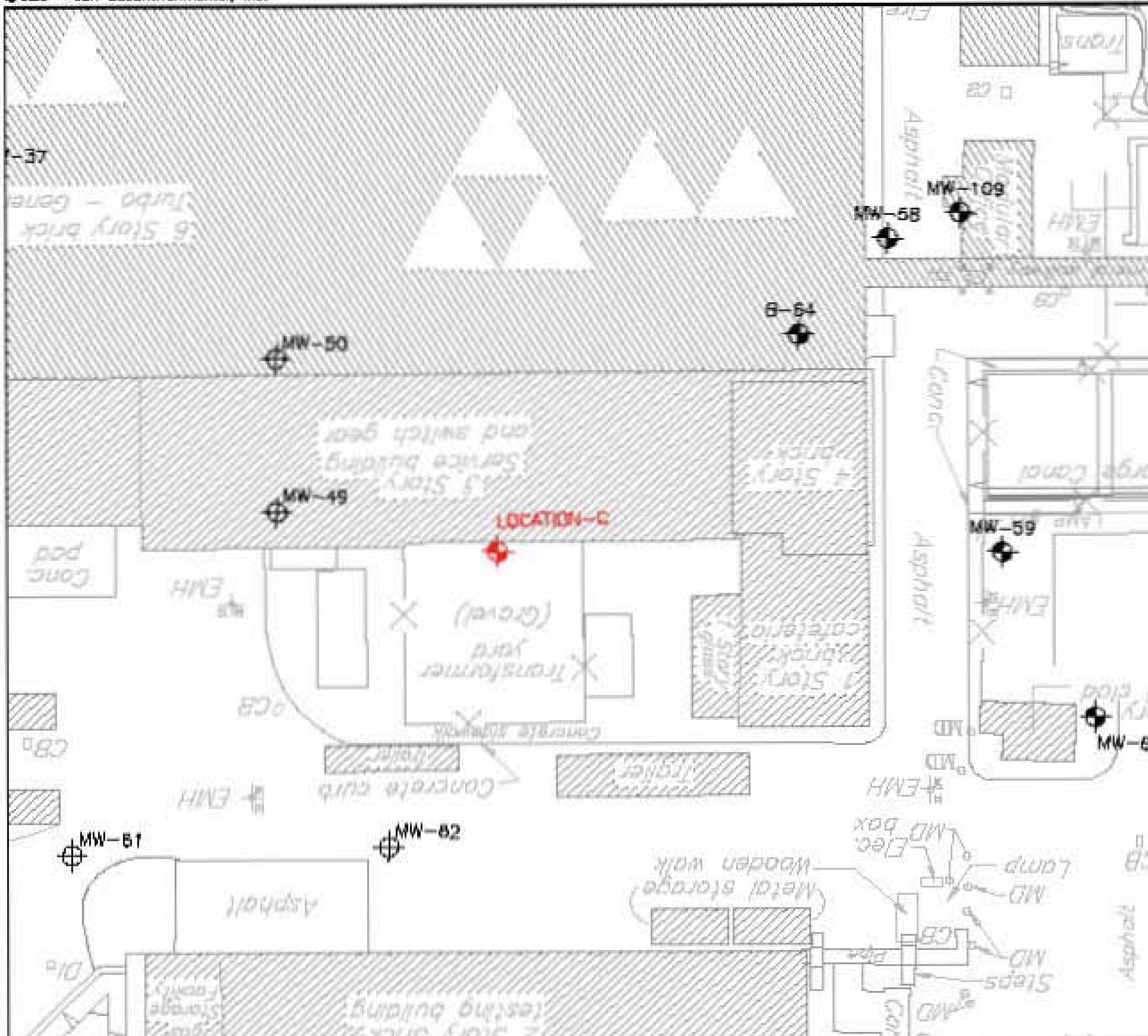

LEGEND:

MW-39	MONITORING WELL
B-64	SOIL BORING
LOCATION-A	HYDRAULIC CONTROL WELL

NOTES:

1. BASE MAP DEVELOPED FROM ELECTRONIC FILES, PREPARED BY BADEY AND WATSON SURVEYING & ENGINEERING PC, COLD SPRING, NY 10516.

FIGURE	4
PROJECT NO.	41.0017869.10

INDIAN POINT ENERGY CENTER
BUCHANAN, NY

REMEDIATION WELL
LOCATION C

REV. NO.	DESCRIPTION	BY	DATE

SCALE
0 50FT.

PROJ MGR:	DW	DRAWN BY:	MJG
DESIGNED BY:	MJG	APPROVED BY:	MJB
REVISED BY:		DATE:	07-31-06

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