A Guide to

Identifying Potentially Favorable Areas to Protect Future Municipal Wells in Stratified-Drift Aquifers

Volume 2
GIS Operator's Manual

January 1999

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Contents

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1. Purpose of Manual

This is the second of two volumes describing NH Department of Environmental Services' Favorable Gravel Well Analysis (FGWA) method, which is intended to be used as part of a comprehensive groundwater protection program. Volume 1 describes the context for a favorable gravel well analysis, explains why and, in general terms, how the analysis is performed, and how the results may be used. This document is intended to provide the technical details to allow a GIS operator to develop a favorable gravel well analysis from publicly available coverages. It is assumed that the reader is familiar with the contents of Volume 1: the FGWA concept and its terminology, as well as GIS concepts and terminology such as coverages, themes, etc.

While this document explains the full process, *much of the pre-processing has already been performed for the state of New Hampshire at NHDES, greatly reducing the time required to develop a map*. The pre-processed coverages include USGS and NWI hydrography, USGS roads, and DES Known and Potential Contamination coverages. While these coverages will suffice in many parts of the state, one can augment them as necessary. For instance, buffered roads may be augmented with DOT and 911 datasets.

For more information about FGWA, contact DES's Drinking Water Source Protection Program at 271-1168 or 271-7061.

2. Method Overview

The intent of the Favorable Gravel Well Analysis pilot project was to develop a method for using a geographic information system to identify those areas of stratified drift aquifers with the greatest potential for development of a large municipal well. Seventy-five gallons per minute (USGS minimum Transmissivity = 1000 ft^2/day) was chosen as the minimum pumping rate of interest to a municipality for planning purposes.

Initial work investigated different methods for developing such a methodology, including using the hydrological modeling tools of Arc/Info, or an Arc/Info Grid approach rather than a traditional vector-based approach. **Hydrological modeling** was ruled out since site-specific hydrogeologic knowledge is required for generating dependable results. The USGS stratified drift data provide spatially generalized variables (transmissivity, saturated thickness, water table elevations), and needs to be augmented for any modeling. **Arc/Info Grid** could have been used as an alternative masking and buffering approach, but the data storage requirements to achieve a grid cell size capable of resolving a 50 foot hydrography buffer were prohibitive.

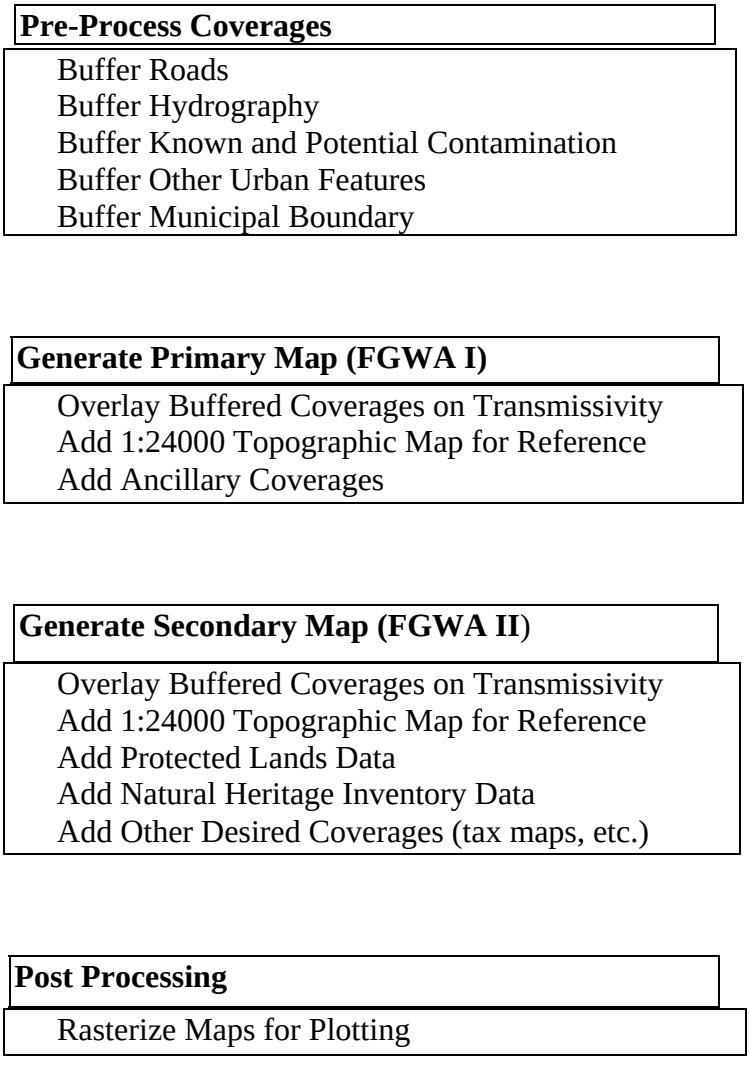
Consequently, a vector-based **masking and buffering approach** was utilized for the Favorable Gravel Well Analysis. Water quantity limitations were addressed by masking those areas of the aquifer with insufficient transmissivity to meet the desired pumping rate. Water quality related datasets (roads, hydrography, known and potential contamination sites, urban data) were buffered according to NHDES requirements, or more conservatively (see Appendix A) in cases where potential for contamination or hazard to public health was thought to be greater.

The flow chart on the following page provides a graphical overview of the process, which includes:

- Pre-processing of coverages
- Generation of the primary FGWA map (FGWA I)
- Generation of the Secondary FGWA map (FGWA II)
- Postprocessing.

For the pilot project, three ESRI software packages were used. Coverage pre-processing was performed in Arc/Info 7.1 using vector format. Actual map-file generation was performed in ArcView 3.0a, and post-processing of map files was performed in ArcPress 1.0. It is worth noting that it may be possible to carry out a limited-extent FGW analysis entirely within ArcView, using buffering and clipping scripts available with the ArcView package or from the ESRI website. Alternatively, one can complete the project within Arc/Info.

Figure 1
Favorable Gravel Well Analysis Process



3. Pre-Processing

Coverage pre-processing consisted of generating buffered coverages from publicly available versions of five types of coverages: Transportation, Hydrography, Contamination, Other Urban Features, and Municipal Boundaries. This pre-processing has been carried out on a statewide basis for all layers and is available from NHDES. Time-sensitive layers such as Contamination or Transportation may need to be supplemented with updated versions (e.g. where new roads have been built).

3.1 Buffers Used in Pre-Processing

In this methodology, there are really only two sanitary protective radii (SPR) that will apply to *urban features and some contamination sites*, depending on the pumping rate of the FGWA map being developed. The lower value is fixed by the chosen 75 gpm minimum FGWA pumping rate, which corresponds to an NHDES 300 ft sanitary protective radius. (For a discussion of sanitary protective radii, see Volume 1, page 10.) Furthermore, 400 ft is the maximum SPR specified by NHDES for any well pumping at more than 100 gpm. The only mid-range NHDES SPR value, 350 feet, corresponds to a well pumping rates between 80 to 100 gpm which in turn correlate to 1087 to 1358 ft^2/d minimum transmissivity. Since the USGS aquifer maps minimum transmissivity values jump from 1000 ft^2/d (75 gpm) to 1500 ft^2/d (110 gpm), the 350 ft SPR will never be used as FGWA buffer. (For a discussion of transmissivity values and pumping rates, see the Appendix to Volume 1).

Table 3-1: The most common FGWA buffers for urban features.

USGS Transmissivity (ft^2/d)	Pumping Rate (gpm)	Buffer (feet)
1000	75-100	300
1500	> 100	400

There are two constraining buffers other than the sanitary protective radii: 50 feet for hydrography, and 1000 ft for contamination sites of serious concern. In some situations, it is necessary to allow additional distances when buffering to allow for physical reality (e.g. road rights-of-way).

None of these buffers guarantees protection from contamination, however, they do allow a first-cut analysis of land availability for municipal well location. Anyone performing FGW analyses may choose to modify these buffers to reflect local knowledge, updated hydrologic science, or modified NHDES regulations (e.g., one might choose to increase the buffer for a closed, but unlined landfill to a value higher than the sanitary protective radius).

3.2 Buffering Roads

Road arcs, as urban features, should be buffered by the appropriate SPR plus ½ the approximate right-of-way to allow for the actual paved surface or cartway. In situations, where road width is indicated by double arcs, the buffer can be reduced to the SPR itself. However, this requires an interactive process.

Discussions with the New Hampshire Department of Transportation indicate that the right-of-way can range from 50 feet for the smallest back-road to 150 feet for a super-highway. Seventy-five to 100 feet is considered common. Actual right-of-way values are site specific, and are not available as attributes in DOT or USGS road coverages. Therefore, approximate values have to be used. Note that buffered roads were used in the pilot study to indicate urbanization as well. (See section on Urban Features Other Than Roads.)

Road coverages are available from 3 sources:

- USGS Digital Line Graphs (DLG's)
- New Hampshire Department of Transportation (DOT)
- New Hampshire 911 Project.

In rural areas of the state, the USGS DLG's will suffice for buffering. In areas of the state which have experienced more recent development, the GIS operator may want to use DOT data augmented with 911 data, if available, for buffering transportation.

USGS Digital Line Graphs

The USGS DLGs were selected for the Henniker pilot project since a road class attribute was readily available that allowed trails to be deselected from buffering. However, since many subdivision roads are not included in the DLGs, it may be necessary to recreate the buffered road coverage using an updated road coverage. When using the DLGs for the FGW analysis use only USGS road classes 1-4. Trails and other undeveloped/very low traffic roads will very likely be acceptable within a sanitary protective radius. Table 3-2 indicates the assumed right-of-way values for the Henniker pilot project.

Table 3-2. Transportation right-of-way values and associated buffers by USGS road class used in the Henniker pilot project.

USGS DLG Class	Description	Approx. Right-of -Way Assumed (ft)	Add to Sanitary Protective Radius (ft)
1	Primary route	100	50
2	Secondary route	75	37.5
3	Road or street	75	37.5
4	Road or street	75	37.5
5	Trail	Do not buffer	Do not buffer
6	Other	Do not buffer	Do not buffer

Department of Transportation Data

The New Hampshire DOT coverage is generally more complete than the USGS in areas of the state that are experiencing development, but road class was not normally included as a coverage attribute at the time of the Henniker pilot project. The DOT has recently provided a statewide coverage to GRANIT which may include a road class attribute as listed in Table 3-3. According to the DOT, any municipality has the final say on road classification.

Table 3-3. Transportation right-of-way values and associated buffers by DOT road class.

DOT Road Class	Description	Approximate Right-Of- Way (ft)	Add to Sanitary Protective Radius (ft)
1	Primary	100 -150	50-75
2	Secondary	50-100	25-50
NA	No class 3	NA	NA
4	Paved, town maintained	50-75	50-75
5	Not maintained by the town	-	-
6	Trail	Do not buffer	Do not buffer
7	Recreational (e.g. State Parks roads)	50-75	50-75

The 911 Project

The 911 project coverage has the advantage of including private roads, but is available only for towns that requested 911 assistance. The 911 data tends to be the smallest dataset. It doesn't include trails, or DOT class 6 or 7 roads. For a road to be mapped, there had to have been a house on the road. Typically, such roads would have 50-75 foot right-of-ways.

3.3 Buffering Hydrography

All sand and gravel wells are required by NHDES to be at least 50 feet *from any surface water including intermittent streams*, hence a 50 ft buffer is used. The intent of NHDES is to avoid bacterial contamination of well water.

Hydrographic features are available from a number of coverages. The USGS Hydrography DLG's are the most encompassing for the state, but often don't capture smaller wetland areas. The National Wetlands Inventory captures much greater detail, but doesn't always agree with the wetland boundaries of the USGS coverage. Furthermore, the NWI coverages are available for only approximately 50% of the state. Wetlands are available from the state's Thematic Mapper based landcover. This uses a 30 ft grid cell size, and is perhaps not as accurate as others since the computerized classification process can misclass other features such as forested wet areas as wetlands. Other wetland delineations are available from GRANIT for certain localities such as Coastal Zone Wetlands. GRANIT suggests that if accuracy is a major consideration, one might take the intersection or union of a number of different wetland data layers for the same quadrangle as defining wetlands. One might use an intersection if a greater certainty for wetland delineation is desired, or the union if one is more concerned with capturing all seasonality effects and less concerned with absolute accuracy.

USGS Hydrography

For the statewide pre-processing and the Henniker pilot project, USGS Hydrography (polygon and arc) and the NWI (polygon and arc) datasets were unioned. The unioned buffer coverages can be augmented by thematic mapper wetlands, coastal zone wetlands as desired.

In the case of hydrography, both polygon features and arc features need to be selected for buffering. See Tables 3-4 and 3-5. For the Henniker pilot project, hyp = 1, 2, 5, or 6 and hya = 4 or 5 were buffered.

Table 3-4. USGS Hydrography DLG polygon attributes.

HYxxx.pat where xxx = GRANIT quad number			
Item	Value	Description	Buffer (ft)
HYP	1	Reservoir	50
	2	Wetland	50
	3	Tidal Feature	Unlikely to occur
	4	Dam	There are only 8 recorded in all USGS DLG's for NH.
	5	River or Stream	50
	6	Lake or Pond	50
	7	Other Surface Water Feature	50, if appropriate

In the Henniker pilot project, the dam crest level for Hopkinton Lake, a Corps of Engineers flood control project, was included under Other Surface Water Features. NHDES regulations indicate that public water supplies are not to be subject to flooding by a 100 year flood or smaller. If a well site is in the flood plain, this requirement can be addressed by raising the well site above the 100 year flood elevation, but such construction adds cost to the wellhead facility. While not actually a 100 year flood level, the Hopkinton lake boundary was included as ancillary information in the Henniker pilot project map to give planners some concept of flood extent for events of this magnitude. Note that the Federal Emergency Management Administration (FEMA) is moving the floodplain graphics from paper to digital format, and digital 100 year floodplains will be available in future.

Table 3-5. USGS Hydrography DLG arc attributes.

HYxxx.aat where xxx = GRANIT quad number			
Item	Value	Description	Buffer (ft)
hya	1	Shoreline	50, if not buffered as polygon
	2	Closure line	na
	3	Apparent Wetland Limit	50, if not buffered as polygon
	4	Stream	50
	5	Intermittent Stream	50
	6	River Bank	50, if not buffered as polygon
	7	Other Surface Water Feature	50, if appropriate, and not buffered as a polygon

NWI

While National Wetlands Inventories exist for only 121 tiles of the state, it is worth including them in the hydrography buffering process, since they provide considerably more detail than that available from the older USGS DLG's.

The NWI coverage feature tables contain an item titled wetcode, which identifies the feature according to Cowardin System.

For polygon features:
Buffer all polygons that were not uplands or universal polygons.
(Wetcode nc " U" and Wetcode nc "OUT")

For arc features:
Buffer all arcs that are not parts of polygons. (Wetcode = "").
Note: non-riverine state boundaries exist in some NWI tiles and may be unintentionally buffered here. *Final buffer coverages must always be manually checked for accuracy.*

3.4 Buffering Urban Features Other Than Roads

Some urban features other than roads can be obtained from the USGS Pipelines, Transmission Lines coverage available from GRANIT. This dataset is described as preliminary and includes pipelines, power transmission lines, telephone lines, power station, substation, hydroelectric plants, airports and an "other" category. Note that these features, once buffered, often add only a small area to the total buffering compared to roads and hydrography.

Only non-water bearing pipelines should be buffered. The type of pipeline must be determined from local sources. In the Henniker pilot project, the only features of note were pipelines. However, these were in upland areas, and were water-bearing for snowmaking.

NHDES is developing a new coverage, Local Inventory, that will comprise locally-developed inventories of potential contamination sources in source water protection areas (contact DES for information on availability). Note that there my be overlap with the Nonpoint coverage and locational accuracy is similar to that of the Nonpoint coverage.

Table 3-6. Attribute and buffers for the USGS urban features point coverage.

PIALL.pat			
ITEM	VALUE	DESC	Buffer
PIA	1	Pipeline	SPR + ½ ROW width (non-water pipelines only)
	2	Power transmission line	SPR + ½ width, if pesticides are or have been applied, otherwise check with DES
	3	Telephone line	SPR + ½ width, if pesticides are or have been applied, otherwise check with DES
	4	Power station	SPR
	5	Substation	SPR
	6	Hydroelectric Plant	SPR
	7	Airport	SPR
	8	Other	SPR

Railroads

Operating railroads are buffered by the sanitary protective radius plus one half of an approximate track bed width. In the Henniker pilot project, the only railroad was abandoned and as such was not buffered.

Urbanization

Delineation of urban areas by satellite imagery such as the Thematic Mapper or SPOT is only 50-80% accurate on a pixel basis. However, in the eastern portion of the state, a landuse classification coverage has been developed for the Route 16 project. The coverage (initially generated from SPOT imagery) was manually modified against aerial photography, and the GIS operator may want to contact GRANIT for this data. Other land use data may be obtained from the regional planning commission.

For the Henniker pilot project, buffered roads were used to indicate urbanization. Buffered roads mask 600-900 feet corridors across the landscape. Consequently, in urban areas, buffered roads become highly concentrated, reducing available lands to a minimum. This is an acceptable first-cut analysis. However, with this approach, *true urbanization will often be understated*, since the new road construction will often not be included, and housing/manufacturing facilities always lie to the side of roads, often by 50 to hundreds of feet.

3.5 Buffering Known and Potential Contamination

Eleven Known and Potential Contamination coverages were used in the pilot project (Table 3-7). Of the eleven, nine are maintained by NHDES. The Pesticides coverage is maintained by the New Hampshire Department of Agriculture, and the Toxic Release Inventory is maintained by USEPA.

The Known and Potential Contamination locations were buffered according to Table 3-7 using the buffer widths in Tables A-1 and A-2 in Appendix A. Table 3-8 lists the items used in the union coverage. Note that these buffers do not vary as a function of well pumping rate. Again, the FGW analysis is intended to be a first cut analysis, not a guarantee of protection from water quality problems. There is not enough data accuracy in the transmissivity, saturated thickness and water table data to create situation specific buffers. Since gradient could not be incorporated, circular buffers had to be used. However, circular buffers encompass a significant amount of land that will not necessarily be affected by any contamination at the site. **While hydrological models imply that in specific circumstances, contamination can be drawn to a well from much further away, 1000 ft was chosen as an arbitrary buffer to reflect a setback that will be between a fully conservative approach which would constrain a large amount of excess land. Local entities, having site specific knowledge may choose to assign different buffers accordingly.**

There is some duplication in the datasets (e.g. underground storage tanks may be common to the contamination site inventory, the underground storage tank inventory, and possibly a RCRA coverage). However, any such duplication does not create a problem for the FGW analysis For instance, the same salt pile can appear in separate polygon and point datasets. In both cases the feature will have been buffered by 1000 ft, resulting in different polygons. The larger, more conservative buffer is the appropriate buffer for the location, and it should encompass the smaller point-buffered polygon. As a general rule, if a point contained in multiple datasets has a choice of buffer distances, choose the larger. (e.g. a RCRA facility may also be listed as a Known Contamination site, and may have the choice of the SPR or 1000 ft buffer.)

If the same point has two different locations in separate coverages, verify the site directly, or check with local experts as to which is correct.

The Known and Potential Contamination coverages having the greatest locational accuracy are c_site and c_area. They are updated monthly at NHDES.

In np_pt and np_poly, mines were assumed to be sand and gravel and were excluded from buffering. However, buffering may be appropriate for hard rock mining operations should such an operation exist on a stratified drift aquifer. Also attribute naming conventions vary somewhat in np_pt and np_poly.

Note also that there are many potential contamination sources, especially those located outside source water protection areas, that may not be included in the available GIS coverages. In all cases the GIS operator should attempt to utilize local expertise where possible.

Finally, it is important to note that if a town develops zoning based on an FGW analysis, the outer boundary of any FGW area should not be used as a build/no-build line. Commonly, landowners will build as close to such a boundary as possible, potentially reducing the FGW area by up to another 300-400 ft (sanitary protective radius). The GIS operator should be aware of these factors and communicate them to town planners. For guidance on the use of FGWA data, please refer to Volume 1 of this set.

Table 3-7. Eleven Known and Potential Contamination Coverages Buffered in the Pilot Project Subsequently Unioned Into u300des

Coverage	Description	Source	Updated	Comment
c_site	Known/Potential Contamination sites	NHDES	monthly	Buffer active sites to Tables A and B in the Appendix. Item Staff <> CLOSED Buffer closed sites to SPR. Item Staff = CLOSED See Table 9 for items.
c_area	Known/Potential Contamination polygons	NHDES	monthly	
np_pt	Point/Non-Point Source Pollution sites.	NHDES	static	Do not buffer mines and quarries. Item Type contains MS or MQ
np_poly	Point/Non-Point Source Pollution polygons	NHDES	static	
ust_site	Underground Storage Tanks.	NHDES	monthly	Avoid overlap with c_site/c_area Item Type does not contain "CU"
r_site	Hazardous Waste Generators (RCRA) Sites Includes small and large quantity waste generators.	NHDES	annually	No documentation is available at this time. Some sites will be inactive. However, all sites will have an urban feature. Hence SPR buffer is appropriate as a minimal distance .
r_area	Hazardous Waste Generators (RCRA) polygons	NHDES	annually	
junkyd	Junkyard locations with at least 50 autos	NHDES	static	Buffered by 1000 ft in all cases.
npdes	National Pollution Discharge Elimination System Outfalls	NHDES	static	Local knowledge may suggest a larger buffer than SPR.
tri	Toxic Release Inventory (air, water, land)	USEPA	periodically	
pesticides	Pesticide Application Polygons	NH Dept of Agriculture	periodically	Buffer entire parcel although pesticides have not necessarily been applied over entire parcel.

Table 3-8. Buffer Items for u300des
(NHDES Union of Eleven Known and Potential Contamination Coverages)

COLUMN	ITEM NAME	WIDTH	OUTPUT	TYPE	ALLOWS SELECTION OF BUFFERED
1	AREA	8	18	F	-
9	PERIMETER	8	18	F	-
17	U300DES#	4	5	B	-
21	U300DES - ID	4	5	B	-
25	INJUNKYD	4	5	B	Junkyards
29	INUST	4	5	B	Underground Storage Tanks
33	INRCRA_PY	4	5	B	RCRA Areas
37	INRCRA_PT	4	5	B	RCRA Sites
41	INNPDES	4	5	B	NPDES Sites
45	INTRI	4	5	B	Toxic Release Inventory Sites
49	INPEST	4	5	B	Pesticide Parcels
53	INNP_POLY	4	5	B	Non-Point Pollution Areas
57	INNP_PT	4	5	B	Non-Point Pollution Sites
61	INCAREA	4	5	B	DES KCS / PCS Areas
65	INCSITE	4	5	B	DES KCS / PCS Sites
69	INSIDE	5	5	I	All “Inside” Polygons

Items beginning with “IN” allow selection of specific buffered KCS / PCS.
(e.g. selecting INJUNKYD = 100 selects the “Inside” polygons of the buffered polygon coverage).

4. Map Generation and Post-Processing

Two map types have been developed for the Favorable Gravel Well Analysis:

- the primary Favorable Gravel Well Analysis map with ancillary information for assisting in interpretation of the results,
- a secondary map contains the FGW analysis overlain with additional ancillary data such as protected lands and Natural Heritage Inventory data or tax maps.

Although other variations are possible, the FGW spatial analysis is usually performed to identify areas that may support the development of 75 gpm wells or 100+ gpm wells. This is a result of the relationships between pre-defined USGS transmissivity ranges, Krasny correlated pumping rates and associated NHDES sanitary protective radii.

No FGWA map should ever be created with a larger scale ratio than 1:24000. To do so misrepresents the product's accuracy.

Two ArcView project templates are available, FGWA_I.apr and FGWA_II.apr. Both contain similar script and menu modifications, as well as sample views and layouts. FGWA_I.apr contains a primary FGWA example for your local area. FGWA_II.apr additionally displays Natural Heritage Inventory data and Protected Lands. Default legends are also provided.

Two scripts have been created for the View menu that assist in moving themes around the Table of Contents: Theme Locate and Theme Move. A North Arrow utility has been added to the View Buttons for adding arrows for groundwater flow direction. This allows easy sizing, placement and rotation of arrows. Generally, it is best to add graphics in the View rather than the layout to avoid having to rework them after a zoom in or out.

ArcView Process - Project Template

There are 3 levels of visual discernment in a FGWA map: the FGW spatial analysis, the background reference map, and ancillary information.

Level 1: Spatial Analysis

It is not necessary to perform the spatial analysis within Arc/Info by unioning all buffered coverages. The same effect for the pilot project can be obtained by prioritizing themes (polygon, line, point, annotation coverages) appropriately in the Table of Contents of an ArcView project, using a white fill and outline for buffered coverages. The theme priorities in the View's Table of Contents for the pilot project are listed in Table 4-1. Coverages comprising the actual spatial analysis reside on the bottom of the View's Table of Contents.

Use the boldest colors for the bottommost aquifer transmissivity theme. This, overlain with the white buffered coverages, is the primary information to be conveyed, and needs to standout relative to the large amount of ancillary information provided.

Level 2: Reference

The reference topographic map (not provided by DES) can be grayed out so that a user can focus on it when necessary, but so that it is not eye-catching. The traditional green background of the USGS topos is made transparent.

Level 3: Ancillary Coverages

Ancillary coverages are intended to provide all available information that may be helpful to end-users in making educated decisions about which FGW areas make the most sense to investigate further. The ancillary coverages of the pilot project include a buffered political boundary, public water supplies, USGS water quality wells, underground storage tanks, RCRA sites and polygons, PCS/KCS sites and polygons, junkyards, point/non-point pollution, Toxics Release Inventory, National Pollutant Discharge Elimination System outfalls, watersheds, source water protection areas, municipal boundary (arc), agricultural pesticide areas, the aquifer/upland boundary, and small streams. Ancillary polygon themes should use non-eye-catching colors and patterns. These themes should augment the spatial analysis only. Care must be taken not to detract from the spatial analysis. Unusual ancillary coverages are listed below.

Political Boundaries and 4000 Foot Buffer

Four thousand feet is the largest wellhead protection radius used by DES. Including this buffer in a FGWA map recognizes that the area of influence for a given well may extend beyond given political boundaries. This coverage is used to mask out extraneous information from other themes beyond the 4000 ft buffer.

Aquifer Boundary

Use a dark line to delineate the aquifer boundary. If a separate aquifer boundary coverage does not exist, one can be created by selecting the appropriate arcs from the aquifer transmissivity coverage, either in Arc/Info or as a shapefile in ArcView.

Source Water Protection Areas

SWPA polygons were simply outlined, rather than hatched. Shading of SWPA's tended to interfere with overall map legibility. Town officials appreciate having all SWPAs on a single map for reference.

Groundwater Contours and Flow Direction

The intent in adding groundwater flow direction arrows is to provide enough information that map users can use their own judgement as to whether further research is needed regarding

potential upgradient contamination. Groundwater flows downgradient perpendicular to the groundwater contours. Note that the USGS groundwater contours describe the general regional groundwater table unstressed by major well pumping. They do not depict actual local site flows. Add arrows using the North Arrow button in View.

Natural Heritage Inventory (FGWA II)

The Natural Heritage Inventory dataset is provided as a generalized point coverage. The end map is to depict any NHI site with an off-center 0.75 mile radius circle. This is most easily done by adding a circle graphic of the necessary radius in the FGWA II View (not the Layout).

Rasterization

Postscript files should be created through File-Export rather than File-Print. Enhanced Postscript files use much less disk space than Basic Postscript files, but may create other problems, depending on the hardware/software system. Ensure that temporary file space for ArcPress is greater than or equal to four time the size of the Postscript file to be rasterized. If you do not have ArcPress, try using Adobe Acrobat writer to convert the Postscript fiel to .pdf format.

Legend

The legend should include data sources and the dates of coverage generation. Special notes should be included for map interpretation as necessary (e.g. buffered pesticide coverages were not limited to area of pesticide application). In addition the Map Disclaimer in Appendix B should always be included in any final map.

Process Errors

Please report any suggestions for improving the ArcView template to NHDES at 271-7061.

Table 4-1. Typical Themes Used in the Pilot FGWA Arcview Projects - As Prioritized in the View's Table Of Contents - With Theme-Property-Definition Queries

Coverage	Type	Theme-Properties-Query	Comments
pbbufxxx	ancillary	NA	**xxx = political boundary user-ID** 4000 ft buffered-political-boundary map mask for municipality xxx. Provides a clipped appearance Set display colors: inside = transparent outside = white
pws	ancillary	([Source_act] = "A")	Display only active public water supplies.
ust_site	ancillary	([Type] <> "CU")	Display only intact UST's. Others will appear under c_site, c_area.
r_site	ancillary	NA	No documentation available at this time.
c_site	ancillary	([Staff] <> ""CLOSED")	Display only active PCS/KCS.
		([Staff] = "CLOSED")	Optionally display closed PCS/KCS with different symbols
npdes	ancillary	([status = "ACTIVE MAJOR"]) or ([status = "ACTIVE MINOR"]) or ([status = "DISCHARGING"]) or ([status = "STILL SPRAYING"]) or ([status = "NEW"]) or ([status = ""])	The operator may wish to look at historical sites as well.
tri	ancillary	NA	USEPA. No status item
junkyd	ancillary	NA	Contains only those junkyards with >= 50 autos. The operator may want to augment this with local

			expertise.
np_pt	ancillary	(([Type] <> "MQ") and ([Type] <> "MS"))	Display all types except sand and gravel mines, and quarries (which were not buffered).
pbsdawtxxx	ancillary	NA	xxx = political boundary user-ID USGS water table arcs Clipped to political boundary xxx Not distributed by DES.
wshed (arc)	ancillary	NA	From state watershed coverage.
swpa	ancillary	NA	Formerly Wellhead Protection Areas
pbpxxx	ancillary	NA	xxx = political boundary user-ID
np_poly	ancillary	([Type] <> "MQ") and ([Type] <> "MS") and ([Type] <> "MS,MQ")	Display all types except sand and gravel mines, and quarries (which were not buffered). In np_poly, some mines were classified as both.
r_area	ancillary	NA	No documentation available at this time.
c_area	ancillary	([Staff] <> "CLOSED")	Display only active PCS/KCS.
		([Staff] = "CLOSED")	Optionally display closed PCS/KCS with different symbols
pest	ancillary	NA	
aqbnd	ancillary	NA	Selected from pbsdatmxxx.
nwixxx (arc)	ancillary	([Wetcode] <> "")	xxx = GRANIT tile #

			Display only small streams that are not part of polygons.
hyxxx (arc)	ancillary	([Hya] = 4) or ([Hya] = 5)	xxx = GRANIT tile # Display streams and intermittent streams.
nwixxx (poly)	ancillary	([Wetcode] <> "U") and ([Wetcode] <> "*L1*")	xxx = GRANIT tile # Do not display upland polygons or Limnetic polygons. Lakes were displayed on the topographic map layer, including lake names.
hypxxx (poly)	ancillary	([Hyp] = 2)	xxx = GRANIT tile # Display wetlands delineated on topographic maps.
g_topxxx	reference	NA	xxx = GRANIT tile # Using a grayed version is recommended.
u300des	spatial analysis	([Inside] = 100)	u300des = statewide coverage Display all polygons contained inside the union of buffered junkyards, c_area, c_site, np_poly, np_pt, npdes, pesticide, r_area, r_site, tri and ust_u (intact underground storage tanks) coverages. SPR = 300. See Table 8 for items.
hytr3cxxx	spatial analysis	([Inside] = 100)	xxx = GRANIT tile # Display all polygons contained the union of buffered USGS/NWI hydrography and transportation. SPR = 300. QC the hydrography coverages for possible unwanted polygons as explained in the text.

pbsdatmxxx	spatial analysis	([Tmin] <= 8000) and ([Tmin] >= 2000)	xxx = political boundary user-ID

APPENDICES

Appendix A

Buffers Used in Favorable Gravel-Well Analysis

A buffer of 1000 feet from certain contaminated sites was used in the Henniker FGWA pilot project. Several cautions are in order:

- In New Hampshire, based on the experience of DES Corrective Action Programs, most contamination plumes extend less than 500 feet from their source(s). A few are longer, with rare cases as long as 2-3000 feet. The longest known plume reached 6000 feet due to a unique combination of hydrogeologic and contamination circumstances. However, for most active contamination sites, a 1000 foot setback is expected to provide reasonable protection for most wells located upgradient of the contamination source, if the source has been located accurately. The protection to either side, or downgradient is undetermined due to site specific hydrogeologic and contaminant variability. **Under the right conditions, it is possible for a 75 gpm well to draw in water from considerably more than 1000 ft away, cross-gradient**. Prior to well development or protection efforts for any site, a hydrogeologic consultant should be employed to evaluate the situation.
- The actual extent of contaminant migration from a known source and the associated risk of contamination of groundwater in the surrounding aquifer depends on a number of site-specific factors. Among these are 1) the length of time the contaminant source has existed, 2) the chemical characteristics of the contaminant(s), 3) the groundwater gradient and aquifer hydraulic conductivity and hence groundwater flow velocity at the site, and 4) the depth of the water table below the source. It is essential that anyone performing a favorable gravel-well analysis contact the NHDES Waste Management Division (Tel. 271-3503) and local authorities to identify and buffer appropriately any **unusally large industrial sites, Superfund (CERCLA) sites, or known extensive contamination plumes.**
- Vulnerability of groundwater to contamination at a mapped PCS site depends on both the nature of the activity and aquifer characteristics at the site. An assessment of the risk of contamination associated with a specific activity should include an evaluation of the types of potential contaminants handled or generated and their quantities. The facility's history of compliance with applicable federal and state regulations governing hazardous substances and its willingness to implement appropriate best management practices also affect the risk of a release. Aquifer characteristics of greatest significance are essentially the same as those described in the preceding paragraph.
- It may be possible to reduce a given 1000 ft buffer, especially upgradient of small contamination sites, if onsite data are available [locations are ground-checked, locational accuracy is high, the site transmissivity is well understood, depth to groundwater, groundwater flow direction has been determined, and the location(s), type(s), concentration(s) and extent of contamination are known]. However, the USGS stratified drift data are not accurate enough for this purpose. Transmissivities were manually

interpolated from point data and were based primarily on sediment sampling rather than pump tests. Water level contours were estimated from stream contour lines as depicted on topographic maps, and from well data that were collected at varying times of the year. Therefore, the contours can only be interpreted in the broadest sense of a generalized, unstressed groundwater flow field. It is important to understand the limitations of these data in applying the method.

- Where several hazards such as RCRA (hazardous waste) generators or underground storage tanks are concentrated, it may be advisable to buffer out the entire area, as opposed to leaving small unconstrained pockets in their midst. It may also be advisable to increase the buffer distance in recognition of the increased potential for contamination.
- The closer a large municipal well is placed near to the edge of a favorable gravel-well area, the more critical good wellhead management becomes. Should contamination occur, there is less opportunity for the processes of dilution, binding with sediments, chemical reactions, escape to the atmosphere, or utilization by microbes to reduce the chemical's concentration to a level deemed safe. For municipal level wells (75+ gpm) any potential contamination sources 300-400 ft away are very probably above the well's cone of depression where groundwater will travel the fastest (see Figure on the following page).

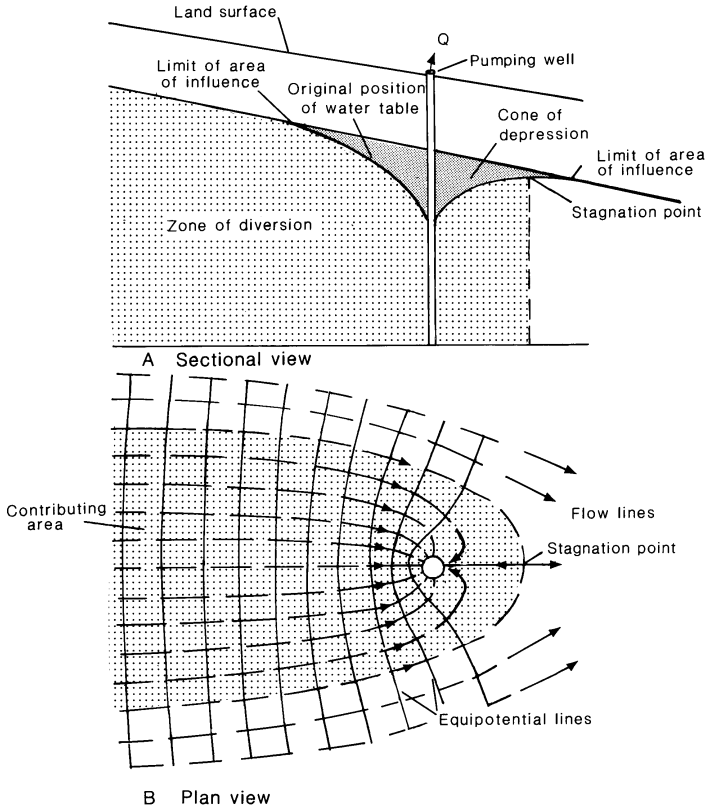


Table A-1

Buffers for Known Contamination Sites

DES Project Type	Description	Chosen Buffer (ft)*	Comments
CERCLA	Superfund Site	1000 minimum	Check with DES Waste Management on size of site, plume length and direction.
COMPLAINTS	Complaints or referrals (town files)	1000	Preliminary category. Further investigation would place the site into a different project type.
FUEL	Leaking bulk storage facilities containing fuel oil	1000	
H2O SAMPLE	Isolated groundwater sample (contaminated water supplies)	1000	Preliminary category. Further investigation would place the site into a different project type.
HAZWSTE	Hazardous waste project	1000	
JUNKYD	Junkyards with more than 50 autos	1000	
LAND/UNLN	Existing unlined landfill or landfill closure	1000	
LAST	Leaking above ground bulk storage facilities containing motor fuel	1000	
LUST	Leaking underground storage tank projects	1000	
MOST	Leaking motor oil storage tank	1000	
NPDES	Pollution discharge to surface water	1000	Not an NH DES groundwater corrective action project type.
OPUF	Leaking residential or commercial heating tanks	1000	
RAPIDINF	Rapid infiltration basins	1000	
SALT STORAGE UNCOVERED		1000	
SEPT/LAG	Septage lagoons	1000	
SEPTIC	Subsurface wastewater disposal systems >20,000 gpd	1000	
SITEEVAL	Unsolicited site assessment/hazwaste types	1000	
SLUD/LAG	Sludge lagoons	1000	
SLUDGAP	Sludge application sites	SPR	DES permits this project type as appropriate recycling.
SNOW DUMPS		1000	Not an NH DES groundwater corrective action project type.

SPILL/RLS	Spill or release	1000	
SPRAYIRR	Spray irrigation projects	SPR	DES permits this project type as appropriate recycling.
STUMP/DEMO	Municipal or commercial stump or demo dump	1000	
TRI	Toxic releases to air inventory	SPR	Impact on groundwater is undetermined. Buffered as an Urban feature.
UIC	Underground injection control-discharge of benign wastewaters not requiring a groundwater discharge permit or request to cease a discharge	SPR	i.e. floor drain closure requests
UWW/LAG	Unlined wastewater lagoons	1000	

*SPR indicates that the sanitary protective radius is the buffer used in the favorable gravel-well analysis.

Table A-2
Buffers for Potential Contamination Sites

DES Project Type	Description	Chosen Buffer (ft)*	Comments
AST	Above ground storage tank	SPR	
GWRELDET	Sites which have groundwater release detection permits and no other defined project type	1000	
HOLDING TANK	Example: temporary storage of garage wastes	SPR	
TRI	Toxic Release Inventory (air)	SPR	Urban Feature
LAND/PRP	Proposed landfill	1000	High concentration of hazardous materials
LAND/LN	Lined landfills		
LWW/LAG	Lined wastewater lagoon	1000	High concentration of hazardous materials
MINING SITES		SPR	
OLD DUMP	Old Dump Sites (non-landfill)	SPR	Many "risk undetermined" but considered minimal.
PESTICIDES	Property boundaries reported as pesticide application.	SPR	Highly regulated. Actual application of pesticide may be anywhere within the property bounds.
PIPELINES		SPR	Not an NH DES groundwater corrective action project type. Non-water pipelines only.
RAILWAYS		SPR	Not an NH DES groundwater corrective action project type. Abandoned railways are not buffered
RCRA	Resource Conservation & Recovery Act- registered hazardous waste handlers	SPR	Registered hazardous waste generator. Not necessarily a site of contamination.
REMED/RCHG	Remediation recharge-treated or remediated groundwater discharged to groundwater	0	Clean water discharge associated with a contamination site; well "watched". Site will also be another project type.
ROADS		SPR	Not an NH DES groundwater corrective action project type. USGS Class 6 are not buffered. (Trails, and abandoned roads)
SALT STORAGE COVERED		1000	
STORM DRAINS		SPR	Not an NH DES groundwater corrective action project type.
TRANS.STA	Solid waste transfer stations with groundwater permits	1000	See GWRELDET above.
UST	Underground storage tank facilities	SPR	

Appendix B

Map Disclaimer Used in FGWA Pilot Project

Note that the Map Disclaimer and FGWA Map Legends need to reflect the correct revision dates for all data sources.

Disclaimer

This map represents digital data available from state and federal agencies as of June 1998. It shows a computerized overlay analysis to determine areas of stratified drift aquifer potentially having both water yield and quality sufficient to serve as large public water supplies. Local land use information and further hydrogeologic analysis are essential to determine the suitability of any location as an actual well site. Buffers used to create this map do not guarantee protection from well contamination. The status of sites and associated buffers are subject to change when contamination has been cleaned up. Similarly, the existing source water protection areas may be revised as more site-specific hydrogeologic information becomes available. The information provided in this map includes a subset of databases developed by the New Hampshire Department of Environmental Services. Development of these databases is ongoing and this map may not contain all existing and potential threats to groundwater. NHDES is not responsible for the use or interpretation of this information, nor any inaccuracies in site names, locations, projected yields, or groundwater flow direction. All information is subject to verification. The data are intended for use at 1:24,000 scale. These data are to be used for planning or educational purposes only. The production of this map was performed under the auspices of the New Hampshire Comprehensive State Groundwater Protection Program with funding support from EPA Region I - New England.

Appendix C

DES Spatial Data Notes

Not included here.